

ACCESSION NUMBER RANGES

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 208)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in December 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



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Washington, DC

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 640 reports, journal articles and other documents originally announced in December 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

TABLE OF CONTENTS

	Page
Category 01 Aeronautics (General)	759
Category 02 Aerodynamics Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.	764
Category 03 Air Transportation and Safety Includes passenger and cargo air transport operations; and aircraft accidents.	783
Category 04 Aircraft Communications and Navigation Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.	787
Category 05 Aircraft Design, Testing and Performance Includes aircraft simulation technology.	790
Category 06 Aircraft Instrumentation Includes cockpit and cabin display devices; and flight instruments.	809
Category 07 Aircraft Propulsion and Power Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.	812
Category 08 Aircraft Stability and Control Includes aircraft handling qualities; piloting; flight controls; and autopilots.	820
Category 09 Research and Support Facilities (Air) Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.	837
Category 10 Astronautics Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	841
Category 11 Chemistry and Materials Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.	841

Category 12 Engineering	844
Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.	
Category 13 Geosciences	N.A.
Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.	
Category 14 Life Sciences	N.A.
Includes sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.	
Category 15 Mathematics and Computer Sciences	852
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.	
Category 16 Physics	855
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.	
Category 17 Social Sciences	857
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.	
Category 18 Space Sciences	N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.	
Category 19 General	N.A.

Subject Index	A-1
Personal Author Index	B-1
Corporate Source Index	C-1
Foreign Technology Index	D-1
Contract Number Index	E-1
Report Number Index	F-1
Accession Number Index	G-1

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

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ON MICROFICHE

ACCESSION NUMBER	→ N86-10033* #	Virginia Polytechnic Inst. and State Univ., Blacksburg, Dept. of Chemistry.	← CORPORATE SOURCE
TITLE	→ A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report		
AUTHORS	→ N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI Apr. 1985 191 p refs		← PUBLICATION DATE
CONTRACT NUMBER	→ (Contract NAG1-300)		← AVAILABILITY SOURCE
REPORT NUMBERS	→ (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF A01 C SCL 01C		← PRICE CODE
COSATI CODE	→ The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.		

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

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ON MICROFICHE

ACCESSION NUMBER	→ A86-11041* #	National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.	
	→ AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS		← TITLE
AUTHOR	→ D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs (AIAA PAPER 85-4076)		← AUTHOR'S AFFILIATION
CONFERENCE TITLE			← CONFERENCE DATE

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 208)

JANUARY 1987

01

AERONAUTICS (GENERAL)

A86-47444#

A METHODOLOGY FOR EVALUATING THE OPERATIONAL PERFORMANCE OF AN AIRCRAFT IN A TACTICAL ENVIRONMENT

R. M. BEATON, M. B. ADAMS, and R. S. SCHABOWSKY, JR. (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 393-402. refs (Contract F33615-82-K-3610) (AIAA PAPER 86-2095)

A methodology for evaluating the operational performance of an aircraft in a tactical environment is presented. The methodology quantifies the operational performance of an aircraft in terms of (1) aircraft reliability/survivability characteristics, (2) aircraft mission planning and maintenance strategies, and (3) the tactical environment. The methodology is used to evaluate and compare measures of mission effectiveness, cost effectiveness and availability for three different flight control architectures: simplex, hardware redundant, and self-repairing. Results indicate that in a wartime tactical environment, the self-repairing flight control architecture is 10 times more cost effective than the simplex and hardware redundant architectures. Author

A86-47601

AIRMEC '85 - AVIATION EQUIPMENT SERVICING: AIRCRAFT AND HELICOPTER MAINTENANCE; INTERNATIONAL EXHIBITION AND CONFERENCE, 4TH, DUESSELDORF, WEST GERMANY, FEBRUARY 26-MARCH 3, 1985, CONFERENCE REPORTS

Duesseldorf, West Germany, Duesseldorfer Messgesellschaft mbH, 1985, 394 p. For individual items see A86-47602 to A86-47617.

Various papers on new aircraft materials, onboard digitalization and its implications for aircraft maintenance practice, and the preservation of long aircraft life are presented. Individual topics addressed include: composites in today's and tomorrow's airliners, nondestructive testing of composites, aluminum-lithium alloys, potential of BITEs in aircraft maintenance, digitalization of avionics in transport aircraft, and practical implementation of a maintenance and engineering system by an airline. Also discussed are: aircraft aging, early corrosion detection and preventive measures, use of low-frequency eddy currents to assist structural integrity auditing, stripping and painting an aircraft, aircraft maintenance in China, planning for minimum overhaul time, third party work, and the affordability of future aircraft maintenance. C.D.

A86-47604

HOW ONE A/C MANUFACTURER TRANSITS TO COMPOSITES

J. KOSHORST (Airbus Industrie, Toulouse, France) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messgesellschaft mbH, 1985, 27 p.

The process of transition from well-proven metal designs to composite-made structures in the Airbus Industrie, is described. Special consideration is given to the A310 structures, including the main landing gear-leg fairing, inner brakes, the CFRP spoiler, and the rudder-sandwich panel. Parts made of advanced composites in the A310, A300-600, A310-300, A300-600R, and A320 aircraft are shown. Introduction of composite materials contributed significantly to cuts in fuel consumption (by reducing the overall weight), production cost (through simplification of the design), and maintenance (by eliminating corrosion problems). I.S.

A86-47607

POTENTIAL OF BITE'S AND WHAT IT MEANS TO AIRCRAFT MAINTENANCE

D. REICHOW (Deutsche Lufthansa AG, Hamburg, West Germany) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messgesellschaft mbH, 1985, 11 p.

The purposes and performance of past and present built-in test equipment (BITE) systems in aircraft line maintenance are discussed. The advantages and shortcomings of BITE in this role as experienced so far are examined. Possible architectures for future BITE systems in all-digital aircraft are examined in terms of how they can fully benefit from the potential which digital technology offers in the area of fast and cost-effective avionics line maintenance. C.D.

A86-47608

WORKING WITH TODAY'S BITE - ONE AIRLINE'S EXPERIENCE

J. E. MILLS (British Airways, London, England) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messgesellschaft mbH, 1985, 6 p.

The question of whether the present built-in testing equipment (BITE) has been successful is examined by relating actual in-flight experience with some of the BITE systems. The performance levels and the drawbacks of the BITEs in the electrical power generating system, the Flight Management Computer and its Control and Display Unit, the electronic flight and electronic engine instrument displays, and the Fuel Quantity Indication System (FQIS) are analyzed. Where the system was performing well, the BITE performance did approach some 95 percent of detectability of predictable faults, but there were many areas where this figure could not be approached. The system of the FQIS is one example where BITE generated codes that have not been substantiated by

01 AERONAUTICS (GENERAL)

the equipment manufacturer or the airframe manufacturer. Among the conditions necessary for making BITEs that approach 100 percent efficiency, is a close liaison between the hardware and software designers and the participation of all the airframe manufacturers planning to use the BITEs that are being designed. I.S.

A86-47609

DIGITALIZATION OF AVIONICS IN TODAY'S AND TOMORROW'S AIRCRAFT AND IMPLICATIONS ON AIRCRAFT MAINTENANCE

G. DARTEYRE (Aerospatiale, Toulouse, France) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegelellschaft mbH, 1985, 39 p.

The digitalization of avionics in transport and its implications for aircraft maintenance are discussed. Present digitalization concepts as exemplified in the A 310 are outlined and their future evolution in the A 320 are examined in the areas of flight deck design, fly-by-wire controls, systems architecture, and on-line maintenance. The BITE (Built-in Test Equipment) concept for line maintenance in the A 310 is briefly described along with the improvements envisioned in the A 320 centralized fault display system. The use of software to modify initial system designs in the A 310, B 767, and A 320 is briefly addressed. Finally, shop maintenance is discussed, including the test philosophy of digital LRUs in the A 310 and the B 767, and the evolution foreseen in this area in the A 320. C.D.

A86-47610

PRACTICAL IMPLEMENTATION OF A MAINTENANCE AND ENGINEERING SYSTEM IN AN AIRLINE

B. MORETTI (Sonovision, Maisons-Alfort, France) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegelellschaft mbH, 1985, 15 p.

The overall structure and individual modules of the SAGIL, a maintenance and engineering system designed to meet the objectives of a medium-sized airline, are described. The system, written in COBOL, is designed to run on a BULL Level 6 computer under the GCOS 6/400 operating system. It integrates the different data processing functions while taking into account the characteristics of communication between the different activity centers of an airline: management, offices, hangars, workshops, and engineering and material departments. The benefits drawn by the airline that has implemented SAGIL include the decreased amount of 'paper documentation rotations', large savings due to greatly improved utilization of stocked supplies, improved maintenance planning and updating of activities, and speeding up of the procurement procedures. I.S.

A86-47612

EARLY CORROSION DETECTION AND PREVENTION MEASURES

K. H. GALDA (Deutsche Lufthansa AG, Hamburg, West Germany) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegelellschaft mbH, 1985, 11 p.

An early corrosion detection, removal, and protection program is described. Various types of corrosion, such as general surface, exfoliation, pitting, intergranular, filiform, galvanic, and stress corrosion are described, together with their most likely localities and causes. In all types of corrosion, except in the case of stress corrosion, the removal of deteriorated material, followed by restoration of the surface either by protective coating or by an appropriate repair, is the recommended procedure. For stress-corrosion-endangered components, a water-displacing fluid,

with wax-forming protection characteristics is recommended. Since stress corrosion is promoted by a chemical aggressive environment, protective coatings are of primary importance. I.S.

A86-47614

STRIPPING AND PAINTING A PLANE - TECHNOLOGICAL AND ECONOMIC ASPECTS

A. CAVALLINI (Alitalia, Rome, Italy) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegelellschaft mbH, 1985, 30 p.

A correct stripping operation is an absolute prerequisite for achieving good results in an aircraft repainting job. The nature of stripping agents, production of toxic fumes, and the disposal of the stripping residuals are discussed, together with the construction specifications of a special stripping/painting hangar and the means of reducing the ground time for the aircraft to the essential minimum. To achieve good adhesion of paint and finish, the installation of an airconditioning system capable of maintaining strictly controlled temperature and humidity was found to be a necessity. Correct thickness and good finish characteristics were achieved using airless electrostatic applicators, which could be positioned over each platform and could be interconnected and moved along the fuselage. The conditions of drying, when no operator is allowed inside the hangar, could be controlled from the control center. A dual-color TV system permits a supervisor to control and coordinate the entire stripping/painting operation. I.S.

A86-47615

AIRCRAFT MAINTENANCE IN CHINA - APPROACHES TO MODERNIZATION

Y. LIU and Y. PAN (Chinese Society of Aeronautics and Astronautics, Beijing, People's Republic of China) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegelellschaft mbH, 1985, 18 p.

The history and the present status of the aircraft maintenance research and management in China are presented. The task of quality control of the technical conditions of all airborne structures includes a feedback of quality information to the designers and manufacturers. Control of the workmanship of the maintenance personnel is part of the quality control program. It is achieved by setting specified requirements for the instruction procedures and material, and by prescribing the specified maintenance assignments and standards. Besides the studies of the methods for diagnosis, correction, and prevention of technical failures, the research of maintenance techniques involves studies of the effects of geographical and climatic conditions, which in China vary between extremes. I.S.

A86-47616

PLANNING FOR MINIMUM OVERHAUL TIME

E. MUELLER (Swissair-Schweizerischer Luftverkehr AG, Zurich, Switzerland) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports . Duesseldorf, West Germany, Duesseldorfer Messegelellschaft mbH, 1985, 15 p.

The experiences of planning and managing an aircraft overhaul program, aimed at achieving maximal aircraft utilization with minimal maintenance, are presented. Maintenance concepts, work schedules, steps in planning advance preparations, job documentation, workshop organization, and deployment of personnel resources are discussed. Advance preparations include drawing up a detailed program of all jobs involved for each heavy maintenance visit and a flow chart comprising about 500 individual activities subdivided into ten aircraft areas and skill categories, which plots the performance of the various individual assignments over two-week periods. The operation of a computerized

maintenance control system for planning and implementing the maintenance activities is described. I.S.

A86-47763**ROBOTIC SYSTEMS CONCEPTS FOR THE RAPID TURNAROUND OF TACTICAL AIRCRAFT IN A BIOCHEMICAL ENVIRONMENT**

E. R. SCHULTZ (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 281-284.

A86-47778**AIRCREW PROTECTION DESIGN, TRAINING AND MISSION MANAGEMENT FOR HIGH ALTITUDE AERODONETIC OPERATIONS**

D. A. PERRENOD IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 1.2-1 to 1.2-6. refs

Physiological factors are noted to impose the ultimate limitation in airborne man-machine systems for high altitude glider/sailplane aerodynamics, or 'aerodonic' flight. Attention is presently given to aircrew protection concepts that furnish effective, off-the-shelf aeromedical solutions for tropospheric and stratospheric crew activities. The systems in question are the High Altitude Flying Outfit (encompassing oxygen breathing and suit pressurization subsystems) as well as cabin heating, insulating garments, a lightweight helmet, and hydration and nutrition facilities. O.C.

A86-48651**THE THEORETICAL BASIS OF HELICOPTER TECHNOLOGY; PROCEEDINGS OF THE SEMINAR, NANJING, PEOPLE'S REPUBLIC OF CHINA, NOVEMBER 6-8, 1985. PARTS 1, 2, 3, 4, & 5**

Seminar sponsored by the Nanjing Aeronautical Institute and AHS. Alexandria, VA, American Helicopter Society, 1985. Pt. 1, 99 p.; pt. 2, 107 p.; pt. 3, 121 p.; pt. 4, 117 p.; pt. 5, 58 p. For individual items see A86-48652 to A86-48674.

The present seminar on current helicopter technology-related research, development, construction and maintenance activities in China and elsewhere considers rotor wakes in nap-of-the-earth flight, the stability and control of a hingless rotor-equipped helicopter with nonuniform induced velocity field, dynamical aspects of advanced rotor system design, the numerical analysis of aeroelastic stability for helicopter rotor blades, coupled aeroelastic hub force reduction, and the finite element analysis and design optimization of semimonocoque airframe structures. Also discussed are FEM for helicopter transmission design, instruments for the preclusion of difficulties in large finite element analysis problems, helicopter handling qualities and flight performance, and microcomputer codes for flight dynamics and performance studies of helicopters. O.C.

A86-48652**THE HELICOPTER TECHNOLOGY OF CHINA**

S.-C. WANG (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 1. Alexandria, VA, American Helicopter Society, 1985, 9 p.

Accounts are given of the development history and current status of the helicopter design, development, and training establishments of the People's Republic of China. Chinese helicopter activity began in the mid-1950s with licensed production of the Soviet Mil-4 aircraft. The present industrial and research system encompasses the Harbin Aircraft Manufacturing Company, the Baoding Propeller Factory, the Low Speed Aerodynamic Research Institute, the Nanjing Aeronautical Institute, and the Flight Test Research Center. O.C.

A86-48976**ICAS, CONGRESS, 15TH, LONDON, ENGLAND, SEPTEMBER 7-12, 1986, PROCEEDINGS. VOLUMES 1 & 2**

P. SANTINI, ED. and R. STAUFENBIEL, ED. New York, American Institute of Aeronautics and Astronautics, Inc., 1986. Vol. 1, 784 p.; vol. 2, 803 p. For individual items see A86-48977 to A86-49133.

Current progress in aeronautics is discussed in reviews and reports of theoretical and experimental investigations. Topics examined include airfoil design, transport aircraft, CAD-CAM, testing of composite structures, shock/boundary-layer interaction, unconventional designs, manufacturing procedures, buckling and postbuckling behavior of composites, active-control technology, computational aerodynamics, multielement airfoils for high angles of attack, navigation, and regulations. Consideration is given to stability and control, maintenance, crash testing, model testing, wind-tunnel methods, airbreathing-engine technology, wind shear, metallic materials, aeroelasticity and structural dynamics, safety, boundary-layer studies, engine control, advanced propfan and turbofan aircraft, noise, hypersonics, landing gear, and propulsion-airframe integration. T.K.

A86-48980#**THE RACE FOR SPEED FROM THE BEGINNING OF AVIATION TO THE PRESENT DAY**

P. LISSARAGUE (Musée de l'Air et de l'Espace, Le Bourget, France) and P. LECOMTE IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 41-59.

A86-48997*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE IMPACT OF EMERGING TECHNOLOGIES ON AN ADVANCED SUPERSONIC TRANSPORT

C. DRIVER and D. J. MAGLIERI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 213-220. refs

The effects of advances in propulsion systems, structure and materials, aerodynamics, and systems on the design and development of supersonic transport aircraft are analyzed. Efficient propulsion systems with variable-cycle engines provide the basis for improved propulsion systems; the propulsion efficiencies of supersonic and subsonic engines are compared. Material advances consist of long-life damage-tolerant structures, advanced material development, aeroelastic tailoring, and low-cost fabrication. Improvements in the areas of aerodynamics and systems are examined. The environmental problems caused by engine emissions, airport noise, and sonic boom are studied. The characteristics of the aircraft designed to include these technical advances are described. I.F.

A86-48999#**AIRBUS-ASSEMBLY CONCEPTS TO IMPROVE PRODUCTIVITY AND FLEXIBILITY IN AIRCRAFT CONSTRUCTION**

J. MASKOW (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 227-231.

The 5-axis CNC riveting system for fuselage skin panel assembly is described. The system is composed of: (1) a riveting machine, (2) component fixture, and (3) a CNC unit. The automatic selection of the 12 rivet types and the automatic rivet position correction facility are examined. The use of a 30 kg riveting machine, the TFH 21PL, for clip-frame riveting is discussed. The application of the automatic riveting assembly system (ARAS) to the fuselage section assembly is considered; the components of ARAS consist of a tooling vehicle, a support beam and guide rail, and dolly bars. I.F.

A86-49000#

CASE STUDIES IN AIRCRAFT MANUFACTURING AUTOMATION

G. L. MICHAELSON (Boeing Commercial Airplane Co., Seattle, WA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 232-237.

The development and implementation of automated equipment and systems at the Boeing Commercial Airplane Company are described in case by case scenarios. A variety of manufacturing operations are covered including fabrication of metal parts, assembly of aircraft structure, building of interior panels, and the automation of electrical wiring operations. The role of robotics in the development of these special equipment packages is outlined.

Author

A86-49037#

PLASTIC OR METAL - THE JUDGEMENT FACTORS

F. E. RHODES (British Aerospace, PLC, Weybridge, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 542-552. refs

The use of CFCs for aircraft components is studied. The weight, cost, and reliability of CFC aircraft components are compared with those of metal components. The design, development, tooling, and testing considerations, and manufacturing, quality control, and technical support costs for utilizing CFCs are analyzed. The application of CFCs to trailing edge structures, flap track fairings, access panels, and flying control surfaces is discussed. The development of a CFC wing demonstrator is described.

I.F.

A86-49052#

MAINTAINABILITY OPTIMIZATION - THE FUTURE CHALLENGE

J. ROSE (Boeing Commercial Airplane Co., Seattle, WA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 697-702. refs

The paper describes the development of a method of optimizing airplane maintenance, using generalized network flow and mixed integer linear programming computer models. The optimization determines the best sequence of activities and best allocation of mechanics of maintenance activities involving more than one mechanic. (For single mechanic tasks the sequence and allocation optimization problem does not exist.) In the model, maintenance tasks are divided into their elemental activities, each activity being interrelated by a precedence network. The purpose of the optimization is to minimize one or more of several objective functions such as total labor, elapsed job time, or the job total cost. Optimization of maintenance activities raised the question of how the results should be presented to mechanics. A real time system was developed for the purpose of presenting instructions to mechanics. Testing the computational procedure and the real time system has included several maintenance task scheduling problems, the largest of which was for removal and replacement of a Boeing 757 airplane engine.

Author

A86-49066#

ON THE FAST REPAIR OF AIRCRAFT PANEL COMPONENTS

S. DEHM and D. WURZEL (DFVLR, Institut fuer Bauweisen- und Konstruktionsforschung, Stuttgart, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 836-843.

In this paper three fields of activity on the fast repair of aircraft composite panels are presented. These activities involved studies to repair delaminations in thin panels by resin injection. The delaminations were caused by impacting the panels in a drop weight tower. The injection method seems feasible, however both panel sides must be accessible. Secondly, a glass/epoxy leading edge component was repaired by different approaches. The component then was tested under bending and torsion. The photoelasticity method was found to be a valuable instrument to

study the efficiency of the applied repair procedures and thus to further develop a qualified repair technique. Finally, flat CFRP panels and stringer stiffened panels with simulated damages were repaired and tested. Special emphasis was placed on employing repair techniques which would enable the fast and simple but substantial restoration of strength and stiffness of the damaged section on the spot, that is under limited accessibility. Testing the panels under compression and torsion loads so far gave promising results.

Author

A86-49067#

AUTOMATED SYSTEMS FOR THE MANUFACTURE OF AIRBUS VERTICAL STABILIZER SPAR BOX IN COMPOSITE MATERIALS

R. OBERFRANZ (Messerschmitt-Boeckow-Blohm GmbH, Hamburg, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 844-848.

A module technique for producing AIRBUS Vertical Stabilizers with Spar Boxes in CFRP is described. This technique allows a high degree of automation with resulting reduction in manufacturing costs. Design principles for composites are discussed in terms of their application to the Spar Boxes. The sequence of production for a Vertical Stabilizer Side-Shell Assembly using the module technique is described. Finally, some successful results using the technique are briefly reported.

C.D.

A86-49084#

THE AIRLINE ENGINEERING ROLE IN THE MANAGEMENT OF SAFETY

D. K. CRAIG (British Airways, London, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1010-1016.

The paper outlines the contribution the Engineering Department of a major International Airline makes in the maintenance and enhancement of Safety Standards. The areas to be covered are: the innovative approaches to the identification of maintenance requirements; the progressive maintenance programmes for the future; the introduction of enhanced safety standards through the airlines; development of techniques such as Engine Health Monitoring, NDT and AIDS; and the improvements in quality standards of staff.

Author

A86-49443

GOING WHERE NO MAN HAS GONE BEFORE

R. B. LEWIS, II (ITT Corp., Defense-Space Group, Nutley, NJ) Veriflite (ISSN 0042-4455), vol. 32, July-Aug. 1986, p. 46-50.

The history of projects of the U.S. Army's Transportation and Engineering Command during the late 1950s and early 1960s, involving non-helicopter vertical lift aircraft, is discussed. The Command oversaw the VZ series programs, of which eleven are discussed. Aircraft and concepts covered range from the HZ-1 (the DeLackner DH-4 Aerocycle, a single-place helicopter in which the pilot and engine are located on a small platform above 15-foot diameter contrarotating rotors) to the General Electric/Ryan VZ-11, a fan-in-wing research aircraft. Other companies that developed aircraft in the series included Hiller, Vertol, Doak, Fairchild, Chrysler, Aerophysics, Piasecki, Avro (concept only), and Lockheed. Such development work was a bold move at the time but the technology was not yet available to assure a high success ratio.

D.H.

A86-49448

MANUFACTURERS SEEK REDUCED COSTS THROUGH NEW FABRICATION TECHNIQUES

S. W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, July 21, 1986, p. 73, 76, 77.

Production and design cost reductions achieved by increasing reliance on automation, robotics and computer simulation and design are seen by aircraft manufacturers as the means to assure industrial growth in a future of anticipated spending level reductions and shrinking budgets. The technology of advanced composites

is one area where cost reductions are being achieved. Grumman's integrated laminating center and automated integrated manufacturing system and McDonnell Aircraft Company's automated ply laminating system are considered. McDonnell is investigating mathematical modeling of composite curing, in order to eliminate slow, expensive, empirical data collection; modeling will permit production increases, improved autoclave utilization, and better quality. McDonnell-Douglas' automated drilling facilities for graphite/epoxy wings for the F/A-18 and the use of computational fluid dynamics codes to study pressures on the F/A-18 are described. Other technological innovations include: superplastic forming/diffusion bonding of titanium, computer simulations for logistic support, and computer-aided engineering/computer-integrated manufacturing (CAE/CIM) to tie all the production advances together. CAE/CIM, according to industry surveys, can permit 70-90 percent reduction in part rejection, 10-30 percent reduction in direct labor costs, 30-60 percent reduction in indirect labor costs, 30-50 percent reduction in floor space, and up to 90 percent reduction in inventory and lead times. D.H.

A86-49464

DESIGN BUREAUS: THE BRAIN DRAINERS. I - TOULOUSE - AIRCRAFT MOBILIZE A TASK FORCE OVER 1700-STRONG

G. PATRI Revue Aerospaciale (ISSN 0065-3780), July-Aug. 1986, p. 16-23. In English and French.

A new building is under construction for the 1700 personnel of the Aerospaciale design department now housed in 16 buildings in Toulouse. The department develops concepts for both existing and future aircraft. Design projects are each placed under the control of a chief engineer who assembles the project team, returning personnel to the pool once goals are reached. Computing resources comprise three Cyber 170/85 devices with 40 Gbyte drives, six VAX 785s, ten SELs for simulation and a leased Cray 1S. All databases are to be stored on a central mainframe for access by all design personnel by the end of 1987. The computers are also used extensively for software engineering for, e.g., the 35 computers on the Airbus 320. The cockpit design features developed at Toulouse are asserted to have been emulated in the 767 cockpit. Finally, it is noted that the main part of all design work is in support of in-service aircraft. M.S.K.

A86-49681#

HARRIER THE VIFFER

D. H. S. MORGAN (Ministry of Defence, Royal Navy, London, England) Aerospace America (ISSN 0740-722X), vol. 24, Aug. 1986, p. 34, 35.

An evaluation is made of the combat capabilities derived by the Harrier VTOL fighter from its capacity for thrust vectoring in forward flight (VIFF), as demonstrated in the Falklands conflict. VIFF thrust changes can decelerate the aircraft very rapidly while instantaneously increasing its rate-of-turn. The effect of this maneuver is both to rapidly shield the jet efflux IR signal from the IR sensors and guided missiles of pursuing fighters, and to lead the pursuer to overshoot the Harrier's position; this leaves the Harrier in the ideal position for a kill. VIFF also allows the Harrier to fly at speeds too slow for conventional aircraft, while retaining full control by means of nose, tail, and wingtip thrusters. O.C.

A86-49682#

CANARD CANARD

A. W. BLACKBURN (Aero Systems Associates, McLean, VA) Aerospace America (ISSN 0740-722X), vol. 24, Aug. 1986, p. 38-41.

An evaluation is made of performance improvements claimed for canard-configuration general aviation aircraft, such as the Avtek 600, OMAC Laser, and Beech Starcraft. Performance gains in the form of drag reduction, stability/control, structural efficiency, and center-of-gravity management are considered in light of intensive experimental studies; all are found to be either equivocal or contradicted by existing data. It is nevertheless noted that the canard configuration yields some structural advantages by precluding the intrusion of the wing spar into the cabin. The pusher

powerplant configuration also results in a quieter cabin than the conventional tractor design. O.C.

N86-31527*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

ELLIPTIC GENERATION OF COMPOSITE THREE-DIMENSIONAL GRIDS ABOUT REALISTIC AIRCRAFT

R. L. SORENSON Mar. 1986 22 p
(NASA-TM-88240; A-86165; NAS 1.15:88240) Avail: NTIS HC A02/MF A01 CSCL 01B

An elliptic method for generating composite grids about realistic aircraft is presented. A body-conforming grid is first generated about the entire aircraft by the solution of Poisson's differential equation. This grid has relatively coarse spacing, and it covers the entire physical domain. At boundary surfaces, cell size is controlled and cell skewness is nearly eliminated by inhomogeneous terms, which are found automatically by the program. Certain regions of the grid in which high gradients are expected, and which map into rectangular solids in the computational domain, are then designated for zonal refinement. Spacing in the zonal grids is reduced by adding points with a simple, algebraic scheme. Details of the grid generation method are presented along with results of the present application, a wing-body configuration based on the F-16 fighter aircraft.

Author

N86-31528# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

INTERNATIONAL AVIATION (SELECTED ARTICLES)

D. YANG and L. ZHONG 4 Apr. 1986 14 p Transl. into ENGLISH from Guoji Hangkong (China), no. 5(267), May 1985 p 2-3; 26; 52

(AD-A166298; FTD-ID(RS)T-0844-85) Avail: NTIS HC A02/MF A01 CSCL 01C

This translation of the Chinese International Aviation contains articles on the following: the use of winglets on the T-5 Transport; and a talk by Payley of Dassault Breguet (France) on Aerodynamicists of the year 2000. The Application of Winglets on Transport-5 Aircraft; Payley of Dassault Breguet (France) talks about the Aerodynamicists of the Year 2000. GRA

N86-31529# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

AN ANALYTICAL METHODOLOGY FOR PREDICTING REPAIR TIME DISTRIBUTIONS OF ADVANCED TECHNOLOGY AIRCRAFT M.S. Thesis

D. C. DIETZ Dec. 1985 226 p
(AD-A167149; AFIT/GOR/OS/85D-3) Avail: NTIS HC A11/MF A01 CSCL 15E

Classical probability theory is applied to analytically combine known or hypothesized subsystem reliability distribution for repair time of an advanced technology aircraft. While repair time of a weapon system is determined by a complex interaction of many factors, the relatively high reliability predicted for advanced technology aircraft justifies several simplifying assumptions which permit an analytical approach. The applicability of the analytical method is examined by comparing analytical repair time distributions with distributions produced by Monte Carlo simulation. Using the Advanced Tactical Fighter as an example, comparisons are performed over a wide range of relevant factors. Overall aircraft reliability emerges as the single critical factor determining the applicability of the method. A simple model is presented for translating the aircraft repair time distribution into measures of aircraft operational effectiveness (availability and sortie generation rate) under a specified concept of operations. The translation model demonstrates how the analytical method for forming a repair time distribution could be used to heuristically determine how to best allocate a reliability and maintainability budget to various subsystems as an aircraft design is developed. GRA

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A86-47659#

SOME ASPECTS OF SUPERSONIC FLOW OVER A CAVITY CASCADE

J. A. EDWARDS and X. ZHANG (Cambridge University, England) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 56-61. Research supported by the Ministry of Defence (Procurement Executive). refs

(AIAA PAPER 86-2025)

The paper presents and discusses some features of supersonic cavity cascade flow which either have not been predicted by existing theories or have not been reported in previous experiments. The flow fields are found to oscillate with the oscillation frequencies in each cavity almost unchanged and with a transfer of power content from higher to lower modes downstream over the cascade. The magnitude of the oscillation is increased downstream over the cascade and the unsteadiness of the flow decreases with the rising Mach number. The skin friction coefficient reduces with the thickening shear layer. There are distinct upstream and downstream influences of a cavity.

Author

A86-47691#

AERODYNAMICS OF DELTA WINGS WITH LEADING EDGE BLOWING

D. A. TAVELLA (Stanford University, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 374-378. refs

(AIAA PAPER 86-2230)

An analysis of the lift augmentation due to a thin jet of air issuing from a slot along the leading edge of a delta wing is presented. The problem is treated with an extension of the method of Brown and Michael, representing the separated flow on the lee side of the wing by a pair of concentrated vortices and corresponding feeding sheets. It is assumed that the jet is not affected by Coanda forces. The analysis produces qualitative agreement with experiments.

Author

A86-47698#

COMPARISONS IN THREE-DIMENSIONALITY IN THE UNSTEADY FLOWS ELICITED BY STRAIGHT AND SWEEP WINGS

J. ASHWORTH and M. LUTTGES (Colorado, University, Boulder) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 446-455. refs

(Contract F49620-83-K-0009)

(AIAA PAPER 86-2280)

A study of the three-dimensional, unsteady flow field about a sinusoidally pitching forward swept wing, a straight wing, and an aft-swept wing was conducted. The flow field behavior was documented using a smoke wire technique and stroboscopic photography for flow visualization. Photographs were taken from both side and top view perspectives to visualize flow patterns at span locations from wingtip to 1.33c inboard. A comparative study between these wings is made by introducing the smoke sheet at identical span locations (percent chord length) for each wing. The unsteady flow field was produced by sinusoidally oscillating the wings about the quarter chord between wing angle-of-attack = 5 and 25 deg at reduced frequency parameters - 0.0, 0.6, 1.0 and 1.4. Static stall characteristics for each wing were analyzed, and seem to directly influence the dynamic vortical structure formation, growth and traversing tendencies. The interactive effects between

dynamic wingtip and leading edge vortices are noted across the span of each wing. The wingtip and leading edge vortex size and location show effects of wing sweep and K value. For some test conditions, multiple vortex formation during the initial phase of the pitching cycle and leading edge vortex splitting were observed.

Author

A86-47699#

VISUALIZATION OF DYNAMIC STALL CONTROLLED BY LARGE AMPLITUDE INTERRUPTED PITCHING MOTIONS

H. E. HELIN, M. C. ROBINSON, and M. W. LUTTGES (Colorado, University, Boulder) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 456-471. refs

(AIAA PAPER 86-2281)

Experimental flow visualization studies of airfoil dynamic stall induced by various combinations of interrupted pitching motions were conducted to further examine the aerodynamic control of unsteady separated flows. An NACA 0015 airfoil section was pitched from 0 to 60 deg angles-of-attack. Short pauses in the ramp motion were programmed at selected angles in the upward pitching motion. Emphasis was placed on identifying specific stages of the vortex-dominated flowfield. The developmental effects induced by changes in the temporal aspects of the forcing motions were characterized for forced flows, relaxed flows and shedding. Pauses during the ramp pitch-up motion and/or changes in the rate of pitch, were seen to dramatically alter flowfield development. Vortex structures were controlled with regard to structure details, dwell times over the airfoil and V/V freestream. In some cases secondary and tertiary vortex structures were eliminated altogether. Motion history changes appear to hold considerable promise for controlling the initiation and development of useable unsteady separated flows.

Author

A86-47700#

CONTROL OF WAKE STRUCTURE BEHIND AN OSCILLATING AIRFOIL

M. C. ROBINSON, H. E. HELIN, and M. W. LUTTGES (Colorado, University, Boulder) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 472-485. refs

(Contract F49620-84-C-0065)

(AIAA PAPER 86-2282)

The initiation, development, and shedding of vortices induced by sinusoidal airfoil motions were examined in the airfoil wake across a range of independent forcing parameters. Then, the interactions of these wakes with a following or trailing airfoil were studied. Coherent, phase-dependent, tandem vortex wake structures emerged from the shedding vorticity of the upstream oscillating airfoil. Consistent interactions of the vortex wake with a trailing airfoil were revealed with both the multiple-exposure, phase-locked, flow visualization measures and the time-dependent surface pressure measurements. Impingement of the tandem vortex wake upon the trailing airfoil produced unsteady pressure distributions resulting in very transient loading. Similar effects in unsteady loading were observed when an auto-rotating flat plate was used to create a vortex-dominated wake. These findings suggest that a consistent, structured wake produced by unsteady separation might be used to produce desired lift characteristics on a trailing, lifting surface. To achieve this, wake impingement angles and trailing airfoil angles of attack interactions must be evaluated in more detail.

Author

A86-48134#

INFLUENCE OF ROTOR BLADE AERODYNAMIC LOADING ON THE PERFORMANCE OF A HIGHLY LOADED TURBINE STAGE

S. H. MOUSTAPHA, U. OKAPUU (Pratt and Whitney Canada, Inc., Longueuil, Canada), and R. G. WILLIAMSON (National Research Council of Canada, Gas Dynamics Laboratory, Ottawa) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. refs (ASME PAPER 86-GT-56)

This paper describes the performance of a highly loaded single-stage transonic turbine with a pressure ratio of 3.76 and a stage loading factor of 2.47. Tests were carried out with three rotors, covering a range of blade Zweifel coefficient of 0.77 to 1.18. Detailed traversing at rotor inlet and exit allowed an assessment of rotor and stage performance as a function of blade loading under realistic operating conditions. The effect of stator endwall contouring on overall stage performance was also investigated using two different contours with the same vane design.

Author

A86-48170#

DEVELOPMENT OF AN EXPERIMENTAL CORRELATION FOR TRANSONIC TURBINE FLOW

F. MARTELLI and A. BORETTI (Firenze, Università, Florence, Italy) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 5 p. Research supported by the Italian National Science Foundation. refs (ASME PAPER 86-GT-108)

Optimization of transonic turbine bladings over a broad range of operating conditions calls for better understanding of the relationship between blade profile loss and cascade geometric parameters. In fact, many of the experimental correlations published to date have failed to take into due consideration transonic effects, while others have considered far too few of the numerous geometric parameters affecting profile loss in transonic flows. Through examination of the experimental data gathered by some 20 authors regarding the effects of the most significant blading geometric parameters on profile losses, a loss correlation procedure has been developed. The procedure is especially advantageous in that it allows continuous updating as new experimental data become available.

Author

A86-48172#

NUMERICAL SOLUTION OF TRANSONIC STREAM FUNCTION EQUATION ON S1 STREAM SURFACE IN CASCADE

Y. HUA and W. WU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p. refs (ASME PAPER 86-GT-110)

Transonic cascading flow fields in turbomachinery are presently calculated by means of a method in which the stream function is obtained with respect to nonorthogonal curvilinear coordinates. In order to overcome the nonuniqueness of the density in transonic flow, as is typical of the stream function method, the velocities at the grid nodes are first obtained through integration of the momentum equation; the densities are then determined from the energy equation. Solutions obtained by applying the method to transonic cascade flows with subsonic or supersonic inlet velocities yields results that are in agreement with experimental data. O.C.

A86-48173#

A THEORETICAL SOLUTION OF THREE-DIMENSIONAL FLOWS IN SUBSONIC, TRANSONIC AND SUPERSONIC TURBOMACHINES - AN EXACT SOLUTION AND ITS NUMERICAL METHOD

T. MIYAZAKI (Kokushikan University, Tokyo, Japan) and N. HIRAYAMA (Tokyo Metropolitan University, Japan) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (ASME PAPER 86-GT-111)

A theoretical solution of a nonviscous flow through subsonic, transonic and supersonic arbitrary turbomachines is presented. The basic relations given by Wu are finally reduced to complex integral equations and then solved rigorously with pseudo-analytic function theories for boundary value problems and conformal mapping theorems which may simplify given flow fields. As the numerical method of the solution successive iteration is used. In the present paper only a schema of computational procedures of the three-dimensional flow is described. Moreover, detailed consideration on problems associated with Wu's model is omitted. The numerical method is easy to accomplish in the whole flow regions, because numerical procedures are done mainly along the boundaries. Numerical examples given are limited to those for subsonic and shock free transonic flows.

Author

A86-48176#

EVALUATION OF THE BLADE-TO-BLADE FLOW FROM A HIGH SPEED COMPRESSOR ROTOR

F. NEUHOFF (Exotech, Inc., Campbell, CA), R. P. SHREEVE (U.S. Naval Postgraduate School, Monterey, CA), and L. FOTTNER (Muenchen, Hochschule der Bundeswehr, Munich, West Germany) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 12 p. Navy-supported research. refs (ASME PAPER 86-GT-117)

A 0.28m single stage transonic fan was operated in a rotor only configuration. Overall performance was measured and radial distributions of inlet and outlet velocity were obtained using time-averaging combination temperature-pneumatic probes. The blade-to-blade velocity and pressure distributions were measured using the Dual Probe Digital Sampling technique (involving two commercial semi-conductor probes of simple design). Data were obtained from hub-to-tip at both near-sonic and at supersonic inlet relative Mach numbers. The rotor losses were derived as blade-to-blade distributions and the shock losses were evaluated as components of the total loss at each radius. Based on the limited data obtained near sonic conditions, a combination of the profile loss model of Kocn and Smith and shock loss model of Dunker was found to predict the measured radial loss distribution quite well. Preliminary observations of rotor shock oscillations are also reported.

Author

A86-48188#

PARTICULATE FLOW SOLUTIONS THROUGH CENTRIFUGAL IMPELLER WITH TWO SPLITTERS

S. ELFEKI and W. TABAKOFF (Cincinnati, University, OH) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 10 p. refs (Contract DAAG29-82-K-0029) (ASME PAPER 86-GT-130)

The small gas turbine engines of such vehicles as helicopters, which frequently employ centrifugal compressors, often operate in environmental conditions marked by high atmospheric particulate content that can cause compressor erosion and performance deterioration. Attention is given to the particulate-laden flow through an impeller whose blading incorporates two differently sized splitter blades. The mean streamline pattern in the meridional plane is estimated by the MERDIL computer code, while an improved panel method is used to calculate the blade-to-blade flow solution; particle trajectories are obtained by means of a direct integration of the particle equations-of-motion to determine particle collisions with blade, hub and casing surfaces.

O.C.

A86-48239#

A METHOD FOR TRANSONIC INVERSE CASCADE DESIGN WITH A STREAM FUNCTION EQUATION

G. MANCHU, L. YIPING, and Y. ZHENG TI (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs

(ASME PAPER 86-GT-189)

A two-part design method is presented for the profiles of blade cascades in transonic flow, where the rotational dynamic stream function equation is deduced in the functional form of calculated coordinates. Local shock waves on the blades' suction surfaces are admissible. After arriving at a given velocity distribution along the suction surface and a given thickness distribution, an inverse method with given velocity distributions on the suction and pressure surfaces is applied. Optimal profile design can then be undertaken on the basis of the calculated optimal velocity distribution on the blade surface. O.C.

A86-48262#

PREDICTIONS OF ENDWALL LOSSES AND SECONDARY FLOWS IN AXIAL FLOW TURBINE CASCADES

O. P. SHARMA and T. L. BUTLER (Pratt and Whitney, East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 10 p. refs (ASME PAPER 86-GT-228)

The development of a semiempirical model for estimating endwall losses is described in this paper. The model has been developed from improved understanding of complex endwall secondary flows, acquired through review of flow visualization and pressure loss data for axial flow turbomachine cascades. The flow visualization data together with detailed measurements of viscous flow development through cascades have permitted more realistic interpretation of the classical secondary flow theories for axial turbomachine cascades. The re-interpreted secondary flow theories together with integral boundary layer concepts are used to formulate a calculation procedure for predicting losses due to the endwall secondary flows. The proposed model is evaluated against data from published literature and improved agreement between the data and predictions is demonstrated. Author

A86-48428

BLENDING METHOD FOR GRID GENERATION

J. STEINHOFF (Tennessee, University, Tullahoma) Journal of Computational Physics (ISSN 0021-9991), vol. 65, Aug. 1986, p. 370-385. refs

A technique is described for forming smooth composite grids by blending together a number of elementary grids for studies of complex flows around and within objects. Each of the elementary grids are generated algebraically, and a nonnegative weighting function is defined for forming the composite grid whose physical coordinates are the weighted sums of the coordinates of the elementary grids. Sample composite grids are provided for the cases of a flow past a sheared cascade airfoil, the same airfoil without shear, past a cascade grid and around stretched and unstretched versions of a wing/canard configuration. M.S.K.

A86-48452

EVALUATION AND REDUCTION OF DRAG [EVALUATION ET REDUCTION DE LA TRAINEE]

J. J. THIBERT (ONERA, Chatillon-sous-Bagneux, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 22nd, Lille, France, Nov. 13-15, 1985. 89 p. In French.

(AAAF PAPER NT 85-01)

Techniques for estimating drag on airfoils (either on the basis of theory or by interpreting wind-tunnel test data) are examined, and approaches to drag reduction are compared, in a review of results presented at the AGARD Special Course on Aircraft Drag Prediction and Reduction held on August 5-8, 1985. The different drag components and their relative importance are recalled; computation techniques used in prediction are briefly characterized;

wind-tunnel measurement techniques and data-analysis approaches are outlined; and experimental drag-reduction designs (including advanced wing profiles, improved wing-fuselage and wing-nacelle joints, boundary-layer-control methods, riblets, and large-eddy breakup) are evaluated. A total of 61 charts, diagrams, graphs, and drawings are provided. T.K.

A86-48454

TRANSITION TO THREE-DIMENSIONAL FLOW AND LAMINARIZATION OF THE BOUNDARY LAYER ON A SWEPT-BACK WING [TRANSITION EN TRIDIMENSIONNEL ET LAMINARISATION DE LA COUCHE LIMITE SUR UNE AILE EN FLECHE]

D. ARNAL, E. COUSTOLS, and M. JELLITI Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 22nd, Lille, France, Nov. 13-15, 1985. 48 p. In French. refs

(AAAF PAPER NT 85-03)

The development and possible control of turbulence of an infinite swept wing are investigated analytically for different sweep and incidence angles. The derivations of the equations and the longitudinal and transverse criteria applied are explained, and numerical results are presented graphically. Laminarization techniques analyzed include optimization of the external velocity distribution and aspiration at the wing surface. T.K.

A86-48455

REDUCTION OF TURBULENT DRAG - TURBULENCE MANIPULATORS [REDUCTION DU FROTTEMENT TURBULENT - MODERATEURS DE TURBULENCE]

E. COUSTOLS and J. COUSTEIX Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 22nd, Lille, France, Nov. 13-15, 1985. 62 p. In French. refs (AAAF PAPER NT 85-04)

The published results of recent investigations of active and passive turbulent-drag-reduction devices are reviewed, and experimental data on large-eddy-breakup (LEBU) devices and riblets are reported. Techniques surveyed include fluid injection, relaminarization using wall aspiration, ionization, Emmons-spot-forcing, riblets, and LEBU devices using thin strips. The effectiveness of the latter two approaches in reducing drag is demonstrated in experiments conducted in the 400 x 300-m working section of an Eiffel-type subsonic wind tunnel at 30-40 m/s. Results are presented in photographs, graphs, diagrams, and tables. T.K.

A86-48458

THEORETICAL AND EXPERIMENTAL ANALYSIS OF SEPARATIONS ON HELICOPTER FUSELAGES [ANALYSE THEORIQUE ET EXPERIMENTALE DES DECOLLEMENTS SUR FUSELAGES D'HELICOPTERES]

A. CLER (Aerospatiale, Division Helicopteres, Marignane, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 22nd, Lille, France, Nov. 13-15, 1985. 29 p. In French. refs

(AAAF PAPER NT 85-08)

A three-dimensional boundary layer method and a source singularity program are used for the analysis of flow around helicopter fuselages and the reduction of drag. Lacking an adequate wake model, the study focuses on the prediction of separation lines, whose location influences fuselage drag. Good correlation between theoretical calculations and experimental results obtained with the Marignane wind tunnel is found for boundary layer studies of the effects of displacement, transition, and friction. For large angles of attack, the separations are found to occur prematurely on the fuselage nose. R.R.

A86-48465

UNSTEADY AERODYNAMICS - FUNDAMENTAL ASPECTS AND APPLICATIONS TO AIRCRAFT DYNAMICS [AERODYNAMIQUE NON-STATIONNAIRE - ASPECTS FONDAMENTAUX ET APPLICATIONS A LA DYNAMIQUE DES AVIONS]

G. DURAND (DRET, Paris, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 22nd, Lille, France, Nov. 13-15, 1985. 77 p. In French. refs (AAAF PAPER NT 85-16)

A review of the 1985 AGARD conference at Goettingen on unsteady aerodynamics. Papers are presented on dynamic stall of swept and unswept oscillating wings, unsteady separate flow of an incompressible fluid around a profile, and a critical look at the dynamic simulation of viscous flow. Also considered are unsteady turbulent boundary layer experiments with rapidly changing freestream conditions, experimental studies of unsteady turbulent boundary layers subjected to intermediate, null and positive pressures, and the unsteady vortex airfoil interaction. Also considered are unsteady aerodynamic effects on aircraft flight dynamics at high angles of attack, nonlinear problems in flight dynamics involving aerodynamic bifurcations, and the effects of aerodynamic lags on aircraft responses. R.R.

A86-48568#

MEASUREMENT OF THE PRESSURE COEFFICIENT AT A SQUARE WING IN TRANSONIC-SUPERSONIC FLOWS AND COMPARISON WITH THEORETICAL RESULTS [MESSUNGEN DER DRUCKBEIWERTE AN EINEM RECHTECKIGEN TRAGFLUEGEL IN TRANSSCHALL-UEBERSCHALLSTROEMUNGEN UND VERGLEICH MIT THEORETISCHEN ERGEBNISSEN]

U. WEISENSEE Aachen, Rheinisch-Westfaelische Technische Hochschule, Fakultaeet fuer Maschinenwesen, Dr.-Ing. Dissertation, 1984. 119 p. In German. refs

Pressure coefficient measurements were performed on a square wing at the upper surface of the DFVLR Cologne trisonic wind tunnel at Mach numbers 1.25, 1.4, 1.8, and 2.2 and an angle of attack ranging from -9 deg to 4 deg. The resulting flow were visualized with oil images and diagrammatically compared with theoretically obtained coefficients. The theoretical values were obtained by using the boundary value problem solution for the axial disturbance velocity found by Carafoli and Nastase, which satisfies the linearized three-dimensional hyperbolic equation and the boundary values on the characteristic surface, at the body contour, and to an infinite distance upstream. Comparison between experimental and theoretical results confirmed the three-dimensional solution to the boundary value problem, except for a small strip along the leading edge and the side edges. C.D.

A86-48653

A STUDY OF THE ROTOR WAKE IN NAP-OF-THE-EARTH

C. HE and Z. GAO (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 1. Alexandria, VA, American Helicopter Society, 1985, 24 p. refs

In this paper, an investigation of the ground vortex, a significant aerodynamic phenomenon in rotor aerodynamics of nap-of-the-earth flight, is carried out. Based on the analysis of the rotor wake near the ground, a theoretical method, including the analytical model, the formulae and the computer program, has been established which can be used for calculation of the ground vortex longitudinal position, height above ground, and strength. By using a free wake model with the ground vortex taken into account, the distribution of induced inflow at the rotor disc is also calculated. All results from the calculation are compared with experimental data available, and good agreement is obtained.

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OVERVIEW OF HELICOPTER WAKE AND AIRLOADS TECHNOLOGY

A. J. LANDGREBE (United Technologies Research Center, East Hartford, CT) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 1. Alexandria, VA, American Helicopter Society, 1985, 23 p. Research supported by the United Technologies Corp., Army, and NASA. refs

An overview of helicopter aerodynamics technology is presented with emphasis on rotor wake and airloads methodology developed at the United Technologies Research Center (UTRC). The evolution over the past twenty years of various levels of computerized wake geometry models at UTRC, such as undistorted wake, prescribed empirical wake, predicted distorted wake, and generalized wake models for the hover and forward flight regimes, is reviewed. The requirement for accurate wake modeling for flow field and airload prediction is demonstrated by comparisons of theoretical and experimental results. These results include blade pressure distributions predicted from a recently developed procedure for including the rotor wake influence in a full potential flow analysis. Predictions of the interactional aerodynamics of various helicopter components (rotor, fuselage, and tail) are also presented. It is concluded that, with advanced computers and the rapidly progressing computational aerodynamics technology, significant progress toward reliable prediction of helicopter airloads is foreseeable in the near future. Author

A86-48762

A STUDY OF THE RELATIONSHIP BETWEEN NONLINEAR CHANGES IN THE LIFTING FORCE AND THE VORTEX STRUCTURE OF FLOW AROUND A LOW ASPECT RATIO WING AT LARGE ANGLES OF ATTACK [ISSLEDOVANIIE SVIAZI Nelineinogo izmeneniia pod'emnoi sily i vikhrevoi struktury obtekaniiia kryla malogo udlineniia na bol'shikh uglakh ataki]

O. A. BURYGIN, G. I. STOLIAROV, and A. N. KHRABROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 1, 1985, p. 98-103. In Russian. refs

The relationship between the nonlinear change of the lifting force and changes in the vortex structure of flow around low aspect ratio wings and fuselage-wing configurations is investigated over a wide range of angles of attack. In particular, attention is given to the effect of the wing planform and of the angle of sideslip on the angle of attack dependence of the total coefficient of the normal force and on the flow pattern around models at low subsonic velocities. The angles of attack at which vortex filaments start to break up near the trailing edge of the wing are estimated. V.L.

A86-48769

HYPOTHESIS OF TWO-DIMENSIONAL CROSS SECTIONS FOR A WING OF FINITE SPAN AT SUPERSONIC VELOCITIES [GIPOTEZA PLOSKIKH SECHENII DLIA KRYLA KONECHNOGO RAZMAKHA PRI SVERKHZVUKOVYKH SKOROSTIAXH]

A. T. BERLIAND, R. A. BREUSOVA, V. V. KELDYSH, and A. N. MINAILOS TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 1-8. In Russian. refs

The applicability of the hypothesis of two-dimensional cross sections to a swept wing of finite span at supersonic velocities is examined. Results obtained with this method are compared with numerical results obtained in the framework of the three-dimensional Euler equations, and with results of linear theory and experiments. It is shown that, when a shock is attached to the wing leading edge, the above-mentioned hypothesis can be used to calculate the coefficients of the aerodynamic forces and the longitudinal moment of the wing irrespective of its aspect ratio. The hypothesis is inapplicable to wings with a subsonic leading edge. B.J.

A86-48779

EFFECT OF CANTILEVER SWEEP ON THE AERODYNAMIC CHARACTERISTICS OF A WING WITH A PROJECTION IN SEPARATED FLOW [VLIANIE STRELOVIDNOSTI KONSOLI NA AERODINAMICHESKIE KHARAKTERISTIKI KRYLA S NAPLYVOM PRI OTRYVNOE OBTEKANII]

S. B. ZAKHAROV and G. G. SUDAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 85-87. In Russian. refs

A numerical analysis is made of the effect of cantilever sweep (sweepforward, zero sweep, and sweepback) on the aerodynamic characteristics of a wing of finite aspect ratio with a projection. It is assumed that flow separation occurs only on the lateral edges of the projection, having the form of a triangular plate of small aspect ratio. It is shown that, at large angles of attack, a wing with a sweptforward cantilever has better lift properties than wings with sweepback or zero-sweep cantilevers. B.J.

A86-48783

EFFECT OF THE NONEQUILIBRIUM CHARACTER OF THE FLOW AROUND A BLUNT PLATE WITH A BEND ON ITS AERODYNAMIC CHARACTERISTICS [VLIANIE NERAVNOVESNOSTI OBTEKANII NA AERODINAMICHESKIE KHARAKTERISTIKI ZATUPLENNOI PLASTINY S IZLOMOM]

A. L. KOSORUKOV, V. L. MENSHIKOVA, and I. B. RADVOGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 102-107. In Russian. refs

The finite-difference method is used to analyze the effect of nonequilibrium chemical processes on the efficiency of flaps with an upward bend; the example considered involves the investigation of the effect of relaxation processes in air on the force and moment characteristics of a cylindrically blunt plate with a bend. The air is modeled by a six-component inviscid mixture with nonequilibrium chemical reactions. The effect of the parameters of the problem (the angle of attack, the bend angle, and the length of the plate and of the bent part) on the pressure distribution is analyzed, and a comparison is made with the case of an ideal gas. B.J.

A86-48787

DETERMINATION OF THE REQUIRED NUMBER OF CHANNELS FOR CONTROLLING AIRCRAFT WING LOADING FOR SEVERAL CASES OF CALCULATION [OPREDELENIE POTREBNOGO CHISLA KANALOV UPRAVLENIIA NAGRUZHENIEM KRYLA SAMOLETA NA NESKOL'KO RASCHETNYKH SLUCHAEV]

N. V. BRYGIN and P. V. MIODUSHEVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 122-124. In Russian.

The paper presents a method for the computer calculation of the number of channels for the control of wing loading in strength tests using automated multichannel systems. The proposed method was used to calculate the loading of wings of large aspect ratio and a delta wing of small aspect ratio. B.J.

A86-48788

DIVERGENCE OF AN ANISOTROPIC SWEEPFORWARD WING [DIVERGENTSIYA ANIZOTROPNOGO KRYLA S OBRATNOI STRELOVIDNOST'YU]

V. V. KOBELEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 125-130. In Russian. refs

An analysis is made of the problem of maximizing the critical divergence velocity of a sweptforward wing made of an anisotropic composite material by an appropriate choice of the orientation of the anisotropy axes of the material with respect to the wing axis. Equations describing the wing deformation are derived by means of the generalized Rayleigh-Ritz method. The perturbation method is used to obtain an approximate solution to the equations describing wing divergence. It is shown that the divergence velocity increases significantly when a certain relationship is established between the stiffness characteristics of the wing and sweep angle. Results are presented for GFRP and boron-epoxy composites. B.J.

A86-48801

THE EFFECT OF THE ASPECT RATIO OF THE CYLINDRICAL SECTION ON THE FUSELAGE DRAG AT TRANSONIC FLIGHT VELOCITIES [VLIANIE UDLINENIIA TSILINDRICHESKOGO UCHASTKA NA SOPROTVIENIE FIUZELIAZHA PRI OKOLOZVUKOVYKH SKOROSTIAKH POLETA]

V. V. VYSHINSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 3, 1985, p. 110-113. In Russian.

A study is made of the effect of the aspect ratio of the cylindrical section of a fuselage on the friction resistance of the fuselage in nonseparated flow, on the critical Mach number, and on the wave drag at supersonic velocities of the incoming flow. The full drag is determined as a function of the aspect ratio of the cylindrical section for both wind-tunnel and full-scale Reynolds numbers. The results are presented in graphical form. V.L.

A86-48802

THE DRAG OF A PAIR OF BODIES AT SUPERSONIC FLIGHT VELOCITIES [SOPROTVIENIE PARY TEL PRI SVERKHZVUKOVYKH SKOROSTIAKH POLETA]

V. E. BELOV, V. S. KHEBNIKOV, and P. G. TSYGANOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 3, 1985, p. 114-117. In Russian. refs

The drag of a pair of bodies (a cone or cylinder in front and a disk in the rear) is investigated ballistically for Mach 1.2-2.1 and Reynolds numbers of 4×10^5 to the 5th - 10^6 to the 6th. Test results are presented in the form of schlieren photographs of the model flow pattern and drag coefficient vs Mach plots. The drag crisis phenomenon, i.e., an abrupt increase in the model drag over a narrow Mach range, is discussed. V.L.

A86-48806

METHOD FOR CALCULATING PRESSURE DISTRIBUTION ON THE SURFACES OF WINGS WITH SLIT MECHANIZATION [METOD RASCHETA RASPREDELENIYA DAVLENIYA PO POVERKHNOSTI KRYL'EV SO SHCHELEVOI MEKHANIZATSIEI]

V. S. IRAKLIONOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 1-7. In Russian. refs

A modified vortex-surface approach is used to develop a method for calculating the potential incompressible flow past a wing of finite span with slit mechanization of the flaps. A system of Fredholm equations of the second kind is obtained for velocity projections on the wing surface and the mechanization elements; a numerical solution is obtained iteratively. As an example, the pressure distribution over an NACA 23012 airfoil with an NACA 23012 external flap is determined. B.J.

A86-48807

METHOD FOR CALCULATING SUBSONIC IDEAL-GAS FLOW PAST AN AIRCRAFT [METODA RASCHETA OBTEKANIIA LETATEL'NOGO APPARATA DOZVUKOVYM POTOKOM IDEAL'NOGO GAZA]

A. N. LIUBIMOV and I. S. SOROKIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 8-16. In Russian. refs

The proposed method for calculating the steady potential subsonic flow of an ideal gas past an aircraft consists of (1) an aircraft data input procedure and (2) a method for determining the gas-flow parameters on the aircraft surface. The first procedure involves the replacement of aircraft elements by a combination of compartments whose surfaces are defined by an analytical relationship. The second procedure involves the representation of the potential of perturbed velocities as the sum of potentials from sources distributed on the aircraft surface and from dipoles distributed on midsurfaces of the lifting elements. As an example, pressure coefficients are determined for a fuselage-wing configuration at a freestream Mach number of 0.113 and an angle of attack of 3.77 deg. B.J.

A86-48808

METHOD FOR THE VISUALIZATION OF SUBSONIC GAS FLOWS [METOD VIZUALIZATSII DOZVUKOVYKH GAZOVYKH POTOKOV]

A. V. DOVGAL, V. V. KOZLOV, and M. P. RAMAZANOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 17-25. In Russian. refs

The smoke-wire method of flow visualization is described; the published literature on this method is reviewed; and the advantages and range of its use in subsonic aerodynamics are examined. The capabilities of this method are demonstrated for examples involving the visualization of flow around wings, three-dimensional flows, and unsteady flow phenomena (e.g., T-S waves in laminar-turbulent transition). B.J.

A86-48809

ACCELERATION OF THE CONVERGENCE OF METHODS FOR CALCULATING TWO- AND THREE-DIMENSIONAL TRANSONIC FLOW PAST BODIES IN AN UNBOUNDED STREAM [USKORENIE SKHODIMOSTI METODOV RASCHETA PLOSKOGO I PROSTRANSTVENNOGO TRANSVUKOVOGO OBTEKANIYA TEL V NEOGRANICHENNOM POTOKE]

N. A. VLADIMIROVA, V. V. VYSHINSKII, S. V. LIAPUNOV, and I. A. M. SEREBRIISKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 26-34. In Russian. refs

It is shown that the presence of an infinitely remote point in the calculation domain is the main cause of the slow convergence of finite-difference methods which map the outer part of the body onto a finite domain. With the aim of convergence acceleration, a far-field 'freezing' algorithm is used in grid calculations after doubling. The use of this algorithm in calculations of two- and three-dimensional transonic flows of an ideal gas makes it possible to reduce the calculation times. Results are presented for a swept wing ($\chi = 30$ deg) at near-critical (0.8) and supercritical (0.85) Mach numbers. B.J.

A86-48812

DETERMINATION OF OFF-DESIGN FLOWRATES ACCORDING TO THE POSITION OF BRANCHING POINTS ON AN UNDER-THE-WING (OVER-THE-WING) AIR INTAKE [OPREDELENIE NERASCHETNYKH RASKHODOV PO POLOZHENIIU TOCHEK VETVLEENIIA NA PODKRYL'EVOM /NADKRYL'EVOM/ VOZDUKHOZABORNIKE]

V. M. SHURYGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 53-58. In Russian.

The main term in the dependence of the off-design flowrate on the position of the branching point on an under-the-wing (over-the-wing) air intake is determined. Results are presented for a thin airfoil and a swept wing of infinite span. B.J.

A86-48815

SIMILARITY CRITERIA FOR A CIRCULATION CONTROL AIRFOIL [O KRITERIIAKH PODOBIIA DLIYA PROFILIA S UPRAVLIAEMOI TSIRKULIATSIEI]

M. N. KOGAN and I. N. SOKOLOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 84-88. In Russian. refs

A simple relationship between airfoil lift increment due to the Coanda effect on a rounded trailing edge and Coanda-nozzle thrust is established on the basis of dimensionality theory and an analysis of experimental data. The features of a wing composed of such profiles are examined. B.J.

A86-48816

DETERMINATION OF THE AERODYNAMIC CHARACTERISTICS OF SEPARATED FLOW PAST A WING WITH ALLOWANCE FOR SLIGHT UNSTEADINESS INDUCED BY CHANGES IN ANGLE OF ATTACK [OPREDELENIE AERODINAMICHESKIKH KHAARAKTERISTIK OTRYVNOGO OBTEKANIYA KRYLA S UCHETOM SLABOI NESTATSIONARNOSTI, VYZVANNOI IZMENENIEM UGLA ATAKI]

A. V. VOEVODIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 89-93. In Russian.

Differences between lift coefficients for unsteady and steady flows are calculated for the example of separated flow past a rotating delta wing of small aspect ratio in the framework of the ideal-fluid model. It is shown that there exists a rotation-axis position (independent of the angle of attack and the angular velocity) where the lift coefficients of the unsteady and steady flows coincide. An example of flow calculation in the case of periodic variations of the angle of attack is presented, and a method is proposed for improving the accuracy of the determination of the lift coefficient in steady flow on the basis of lift-coefficient measurements of a rotating wing. B.J.

A86-48817

TRANSONIC FLOW PAST THE ROOT SECTION OF A WING WITH SWEEPBACK AND SWEEPFORWARD [TRANSVUKOVOE OBTEKANIE KORNEVOI OBLASTI KRYLA S PRIAMO I OBRATNOI STRELOVIDNOST'IU]

M. N. NEKRASOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 4, 1985, p. 94-99. In Russian. refs

Pressure distributions on a wing model with a sweep angle of \pm or -45 deg at transonic flow ($M = 0.8-1.6$) velocities are investigated. Flow characteristics in a local supersonic zone are examined, and values of the pressure drag coefficient for the root section of a wing with sweepback and sweepforward are determined. Experimental results are compared with the calculations of Pavlovets and Nekrasova (1981). B.J.

A86-48822

NONUNIQUENESS OF LAMINAR SEPARATED FLOW AROUND AN AIRFOIL AT ANGLE OF ATTACK IN THE KIRCHHOFF SCHEME [NEEDINSTVENNOST' LAMINARNOGO OTRYVNOGO OBTEKANIYA PROFILIA POD UGLOM ATAKI V SKHEME KIRKHGOFA]

A. N. KHRABROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 1-9. In Russian. refs

Separated flow around an airfoil with a thickness of the order of $O(Re \exp -1/16)$ in the presence of an angle of attack of the same magnitude is analyzed, the separation being modeled by a zone of constant Kirchhoff pressure. Asymptotic viscous conditions for pressure are satisfied at the separation points on the airfoil. Particular attention is given to flow around airfoils with a round leading edge with a finite opening angle and a reversal point at the trailing edge, with allowance for viscous-inviscid interaction during the separation. It is shown that the solution of the corresponding nonlinear equations is nonunique in the general case. B.J.

A86-48824

EXPERIMENTAL INVESTIGATION OF A BOUNDARY LAYER ON A SCHEMATIC AIRCRAFT MODEL [EKSPERIMENTAL'NOE ISSLEDOVANIE POGRANICHNOGO SLOIA NA SKHEMATIZIROVANNOM MODELI SAMOLETA]

A. V. KOLESNIKOV, K. A. POCHKINA, and A. G. PROZOROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 22-30. In Russian. refs

Experimental results are presented on the characteristics of a three-dimensional boundary layer on the wing and fuselage of schematic aircraft model consisting of the combination of a two-dimensional delta wing with rounded edges and a cylindrical fuselage with a sharp front at low subsonic velocities of the impinging flow. Unseparated flow around the wing and fuselage is observed at angles of attack of 0-6 deg. The static pressure is constant (within the bounds of measurement accuracy) with respect

to the boundary layer thickness (BLT), and the intensity of secondary flows is low. The velocity distribution with respect to the BLT on the greater part of the wing and fuselage surface is in agreement with available empirical velocity profiles. Values of surface friction coefficients determined by different methods according to the velocity profiles are found to agree well. B.J.

A86-48825

DETERMINATION OF THE SHAPE OF A JET ISSUING FROM A CYLINDER OF FINITE LENGTH AROUND WHICH A SUPERSONIC STREAM FLOWS AT SMALL ANGLE OF ATTACK [OB OPREDELENIY FORMY STRUI, VYTEKAIUSHCHEI IZ TSILINDRA KONECHNOI DLINY, OBTEKAEMOGO POD MALYM UGLOM ATAKI SVERKHZVUKOVYIM POTOKOM]

A. E. VNUKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 31-39. In Russian.

Linear theory is used to consider the problem of determining the shape of a jet issuing from a hollow thin-walled cylinder of finite length around which a supersonic stream flows at small angle of attack. This problem models the flow of an external stream around an engine nacelle. An integral equation, solvable by the Laplace method, is obtained for determining the jet shape. It is shown that, depending on the length of the cylinder, the jet can be deflected either along or against the external stream.

B.J.

A86-48833

THE USE OF THE MAGNETIC AEROHYDRODYNAMIC ANALOGY METHOD TO SIMULATE THREE-DIMENSIONAL FLOW PAST AIRCRAFT, TAKING POWERPLANT OPERATION INTO ACCOUNT [MODELIROVANIYE METODOM MAGNITNOI AEROGIDRODINAMICHESKOI ANALOGII TREKHMERNOGO OBTEKANIYA LETATEL'NYKH APPARATOV S UCHETOM RABOTY SILOVYKH USTANOVOK]

V. N. ZHELEZNIYAK, L. N. MAKAROV, V. N. MALNEV, and V. V. PIROGOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 97-101. In Russian. refs

The paper presents a novel approach to the magnetic aerohydrodynamic analog simulation of three-dimensional unseparated flow past aircraft models in the framework of an ideal incompressible fluid scheme. The novelty of the approach consists in the simulation of a continuous sheet of free vortices in the near wake of the lifting surfaces to their rollup into concentrated cores by a metal foil, as well as in the simulation of three-dimensional gas jets of the powerplant. The analog simulation results agree satisfactorily with available experimental data. B.J.

A86-48834

WAVE DRAG OF A SUPERSONIC AIR INTAKE AT HIGH SUBSONIC VELOCITIES [VOLNOVOE SOPROTVIENIE SVERKHZVUKOVOGO VOZDUKHOZABORNIKA PRI BOL'SHIKH DOZVUKOVYKH SKOROSTIAKH]

E. V. ALEKSANDROVICH and I. U. A. ZABELIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 102-107. In Russian.

An inviscid unseparated flow model is used to calculate the wave drag coefficient of a supersonic air intake operating in the throttling mode in flow at a freestream Mach number of 0.85. Calculation results are compared with experimental data. It is concluded that, at high subsonic flight velocities, the separation drag constitutes only an insignificant part of the drag connected with the formation of shocks on the outer surface of the casing.

B.J.

A86-48838

SYMMETRIC AND NONSYMMETRIC SEPARATED FLOW PAST A LOW ASPECT RATIO WING WITH A FUSELAGE [SIMMETRICHNOE I NESIMMETRICHNOE OTRYVNOE OBTEKANIE KRYLA MALOGO UDLINENIYA S FIUZELIAZHEM]

M. G. GOMAN, S. B. ZAKHAROV, and A. N. KHRABROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 1-8. In Russian. refs

Asymmetric solutions to the problems of separated flow with no slip are obtained for a delta wing with a conical fuselage in the context of the theory of oblong bodies. The stability of symmetric and nonsymmetric solutions against arbitrary small perturbations is analyzed. Nonsymmetric separated flow is shown to result from a stability loss by symmetric vortex structures. The possibility of an aerodynamic hysteresis due to a change in the angle of attack is demonstrated.

V.L.

A86-48839

FLOW OF AN IDEAL FLUID IN THE CORE OF A VORTEX SHEET [TECHENIE IDEAL'NOI ZHIKOSTI V IADRE VIKHREVOI PELENY]

A. M. GAIFULLIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 9-15. In Russian. refs

The paper is concerned with three-dimensional separated flow past wings that are curved in accordance with a power law and have a power-law planform. An asymptotic solution is obtained for the problem of determining the flow field of an ideal fluid in the core of a vortex sheet.

V.L.

A86-48841

AN ANALYSIS OF FLOW OF A NONVISCIOUS INCOMPRESSIBLE FLUID PAST A WING OF FINITE THICKNESS IN THE PRESENCE OF A SCREEN [RASCHET OBTEKANIYA KRYLA KONECHNOI TOLSHCHINY POTOKOM NEVIAZKOI NESZHIMAEMOI ZHIKOSTI V PRISUTSTVII EKRANA]

A. M. TIMERBULATOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 28-35. In Russian. refs

A method is presented for calculating flow past a wing of finite thickness of arbitrary shape in the presence of an infinite screen. The procedure employs a layer of sources continuously distributed on the lower and upper wing surfaces and also a layer of attached vortices located at the middle surface. The effect of the screen is allowed for by means of a mirror image of the wing. Pressure distributions are calculated for two specific cases, and the results are compared with experimental data.

V.L.

A86-48842

A STUDY OF THE CHARACTERISTICS OF SEPARATED FLOW PAST WINGS AND LIFTING SYSTEMS [ISLEDOVANIYE OSOBENNOSTEI OTRYVNOGO OBTEKANIYA KRYL'EV I NESUSHCHIKH SISTEM]

O. A. BURYGIN, E. P. VIZEL, A. G. GONCHAR, and A. N. MATROSOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 36-45. In Russian. refs

The characteristics of the formation of a vortex wake in flow past a delta wing of aspect ratio 1.42 and past lifting systems with front wings or projections are analyzed. The interference of these vortex-generating elements with the main wings of various planforms is discussed.

V.L.

A86-48843

THE EFFECT OF EQUILIBRIUM AIR PROPERTIES AND MACH NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF A FLIGHT VEHICLE [VLIYANIE RAVNOVESNYKH SVOISTV VOZDUKHA I CHISLA MAKHA NA AERODINAMICHESKIE KHARAKTERISTIKI LETATEL'NOGO APPARATA]

N. A. BLAGOVESHCHENSKII, A. P. KOSYKH, A. N. MINAILOS, and B. A. ELGUDINA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 46-54. In Russian. refs

Hypersonic flow past a flight vehicle with a lifting body, whose shape provides self-balancing with respect to pitching under conditions of maximum lift-drag ratio, is investigated numerically and experimentally. The effect of the real air properties on the

force and moment characteristics of a family of bodies formed by cutting sections of various lengths from the rear of the flight vehicle is estimated (with no allowance made for viscosity). V.L.

A86-48849

THE EFFECT OF A KINETIC AIR MODEL ON THE AERODYNAMIC CHARACTERISTICS OF AIRFOILS WITH FLAPS [O VLIJANII KINETICHESKOI MODELI VOZDUKHA NA AERODINAMICHESKIE KHARAKTERISTIKI PROFILEI S ZAKRYLKAMI]

A. L. KOSORUKOV, V. L. MENSHIKOVA, and I. U. B. RADVOGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 103-108. In Russian. refs

With reference to hypersonic inviscid flow past a blunt plate with a bend that simulates an airfoil with a flap, the effect of a kinetic air model on the surface pressure distribution, aerodynamic coefficients, and the position of the pressure center is investigated as a function of the airfoil geometry, angle of attack, and the flap angle. Calculations for flows of an ideal gas and of equilibrium and chemically nonequilibrium air are compared. It is concluded that the equilibrium air model can be used for calculating the aerodynamic characteristics of the airfoil for large angles of attack. V.L.

A86-48981#

THICK SUPERCritical AIRFOILS WITH LOW DRAG AND NLF CAPABILITY

B. EGGLESTON, R. J. D. POOLE (De Havilland Aircraft of Canada, Ltd., Downsview), D. J. JONES, and M. KHALID (National Aeronautical Establishment, Ottawa, Canada) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 60-66. Research supported by the de Havilland Aircraft of Canada, Ltd. and National Research Council of Canada. refs

A family of supercritical airfoils with natural-laminar-flow (NLF) capability has been developed which was designed to have good characteristics with turbulent flow while being capable of supporting up to 70-percent chord NLF in favorable conditions. Tests are reported on airfoils of 16-percent and 21-percent-chord maximum thicknesses in the NAE 0.38 x 1.52-m two-dimensional wind tunnel. At Reynolds numbers up to 10 million, and over a narrow range of Mach numbers close to their design conditions, the airfoils supported extensive laminar flow, and their drag was reduced more than 50 percent relative to values with turbulent boundary layers. At higher Reynolds numbers, the NLF capability diminished rapidly due to reduced boundary-layer stability and other factors. The airfoil cruise drag characteristics at all Reynolds numbers tested (8 million to 20 million) were markedly superior to those of airfoils of similar thicknesses tested previously in the same facility (Whitely, 1984). Author

A86-48982#

DESIGN OF A SUPERCritical AIRFOIL

Z. Y. ZHANG, X. T. YANG (Northwestern Polytechnical University, Xian, People's Republic of China), and B. LASCHKA (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 67-70. Research supported by the Chinese Aeronautical Establishment, Carl Duisberg Gesellschaft, and DFVLR. refs

A supercritical airfoil (NPU2) was designed by specifying shockless pressure distributions at a design point defined by M, C(L), and Re. Weak shock waves still occurred in the wind-tunnel test. A modified airfoil (NPU2M) was then designed using the optimization method of Sobieczky et al. (1978). Later, modified in another way, new airfoils (NPUBS1 and NPUBS2) were obtained. It is found that the aerodynamic characteristics of these airfoils are better than those of NPU2M. Since the optimization method is under the restriction of modifying only a part of a given airfoil contour, it is possible to find better airfoils without this restriction. Author

A86-48983#

INVESTIGATIONS ON HIGH REYNOLDS NUMBER LAMINAR FLOW AIRFOILS

G. REDEKER, K. H. HORSTMANN, H. KOESTER, and A. QUAST (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 73-85. refs

For further operating-cost reduction on transport aircraft, drag reduction by extended laminar flow on wings and empennages is mandatory. With carefully designed airfoils laminar flow can be achieved even at high Mach and Reynolds numbers and moderate sweep angles. With laminar airfoils operating costs decrease on the order of 30 percent. Two-dimensional and three-dimensional stability theory seems to be a good tool for determining the laminar-turbulent boundary-layer transition caused by Tollmien-Schlichting and crossflow instabilities, but it must be checked by extensive flight tests because wind-tunnel tests are not well suited, as a consequence of the microturbulence of the flow and wind-tunnel noise. Author

A86-49007#

EFFICIENT SOLUTION OF THREE-DIMENSIONAL EULER EQUATIONS USING EMBEDDED GRIDS

R. RADESPIEL (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 292-302. refs

For an efficient solution of three-dimensional Euler equations block structured grid generation and Euler codes which use local refinement of a coarse base grid to resolve the flow in regions with high gradients have been developed. Coordinate grids are generated by numerical solution of an elliptic system. A new iterative technique for grid control yields smooth and well distributed grids even near singular lines of H-type sections. The flow solver is based on a well-known finite volume Runge-Kutta time-stepping scheme. Different procedures for the treatment of the zonal boundaries are investigated. The codes are used to calculate transonic flow around the DFVLR F4 wing. The results show that the present grid embedding technique yields a substantial reduction of computational expense without loss of accuracy. Author

A86-49008#

TRANSONIC COMPUTATIONS ABOUT COMPLEX CONFIGURATIONS USING COUPLED INNER AND OUTER FLOW EQUATIONS

U. G. NAVERT and Y. C.-J. SEDIN (Saab-Scania, AB, Linkoping, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 303-312. refs

Modern aircraft, in particular fighters, are characterized by a high degree of geometrical complexity. To master such complicated geometries in transonic computations, it is necessary to rely on small disturbance (transonic small perturbation, 'TSP') formulations on Cartesian grids. Wing boundary conditions are then easily imposed using thin-wing theory while fuselage boundary conditions usually are more difficult to implement. A numerical method for solving the TSP equation about a complex slender configuration emphasizing a consistent treatment of the boundary conditions on the fuselage surface is presented. The basic concept is a decomposition in two coupled inner and outer problems using the theory of matched asymptotic expansions. The outer problem is discretized using a standard three-dimensional finite difference scheme. The inner problem, enforcing the fuselage boundary conditions, is solved as a sequence of cross-flow problems using a linear two-dimensional panel method. Several test runs on a CRAY-1 computer have demonstrated the reliability and robustness of the above procedure. Computed pressure distributions for a number of three-dimensional cases, including one of fighter type, are in good agreement with wind tunnel test data. Author

A86-49009* # National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATION OF THE TRANAIR FULL-POTENTIAL CODE TO COMPLETE CONFIGURATIONS
 L. L. ERICKSON, M. D. MADSON, and A. C. WOO (NASA, Ames Research Center, Moffett Field, CA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 313-323. refs
 (Contract NAS2-11851)

The TranAir computer code solves the full-potential equation for transonic flow by combining a rectangular box of flow-field grid points with networks of surface panels. Complex geometry is easily represented since surface conforming flow-field grids are not used. Application of TranAir to the F-16A is presented for free-stream Mach numbers of 0.6 and 0.90, at an angle of attack of four degrees. Author

A86-49011#
CALCULATION OF FLOW OVER MULTIELEMENT AIRFOILS AT HIGH LIFT

T. CEBECI (California State University, Long Beach), K. C. CHANG, R. W. CLARK, and N. D. HALSEY (Douglas Aircraft Co., Long Beach, CA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 335-342. refs
 (Contract NSF MEA-81-8565)

An interactive boundary-layer procedure has been used to calculate the flow around three two-element airfoil arrangements. The procedure is known to be accurate, is seen as the foundation of a generally applicable calculation method and is used here in comparatively simple form. The calculated results are in close agreement with measurements for angles of attack up to around 10 degrees, with flap-deflection angles of up to 20 degrees. The range of accuracy of the predictions can be extended by incorporation of the wake and this will be required to deal with high angles of attack, high flap deflection angles and airfoil elements with smaller slot gaps than those considered here. Author

A86-49012#
THE HIGH LIFT DEVELOPMENT OF THE A320 AIRCRAFT

J. R. WEDDERSPOON (British Aerospace, PLC, Weybridge, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 343-351. refs

The aerodynamic research and development procedures used by British Aerospace at Weybridge to design the high lift system for the new Airbus Industrie A320 airliner are described. Both the theoretical and the experimental basis are reviewed, including the use made of the large body of data on high lift devices obtained during the UK National High Lift Programme. The background to the choice and subsequent development of the A320 leading edge and trailing edge high lift devices and their optimization on a complete three-dimensional model is discussed. Author

A86-49013#
POTENTIAL FLOW MODELS OF AIRFOILS WITH SEPARATED FLOW

G. V. PARKINSON and W. YEUNG (British Columbia, University, Vancouver, Canada) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 352-359. NSERC-supported research. refs

A long-term program of studying the aerodynamics of airfoils and wings with separated flow through the use of potential flow models is presented. The earlier work includes analytical and numerical thick-airfoil theories for the pressure distribution on airfoils with normal spoilers which use wake sources to simulate wake effects, a thin-airfoil free-streamline theory for the lift and moment on airfoils with spoilers in steady and unsteady flow, and lifting-line theory incorporating the thin airfoil theory for wings fitted with

part-span spoilers. In the new work, an improved analytical wake-source model is described in which airfoils with inclined spoilers or split flaps can be treated, and an additional boundary condition reduces the empiricism to the minimum required in such flow models. Predictions from both the earlier and the new models are shown to be in good agreement with wind tunnel data.

Author

A86-49014#
AN EXPERIMENTAL STUDY OF TURBULENT WAKE/BOUNDARY LAYER MIXING FLOWS

L. J. JOHNSTON (Aircraft Research Association, Ltd., Bedford, England) and H. P. HORTON (Queen Mary College, London, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 360-369. refs

Mean flow and turbulence measurements were made to study turbulent wake/boundary layer mixing in two-dimensional incompressible flow. Both the mixing of a symmetric aerofoil wake with a flat plate boundary layer, and a two-element aerofoil system in a wing/leading-edge slat configuration, are considered. Measurements included transverse through the viscous layers at a large number of stations, and Reynolds normal and shear distributions were measured with hot-wire anemometry. Simple integral methods which are based on self-similar flow development are shown to be inadequate in the presence of strong wake/boundary layer interactions, while a differential boundary layer calculation method together with the k-epsilon turbulence model successfully predicted the present flows. R.R.

A86-49027#
DISORDERED VORTEX FLOW COMPUTED AROUND A CRANKED DELTA WING AT SUBSONIC SPEED AND HIGH INCIDENCE

A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) and C. J. PURCELL (ETA Systems, Inc., Saint Paul, MN) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 457-470. refs

A numerical method that solves the Euler equations for compressible flow is used to study leading-edge vortex dynamics. The particular cases simulated are subsonic flow $M_{\infty} = 0.3$ around a twisted and cambered cranked-and-cropped delta wing at two angles of attack, $\alpha = 12.5$ and 20 deg. This geometry induces multiple leading-edge vortices in a straining velocity field that brings about a spiralling flow instability. The discretization contains over 600,000 cells and offers sufficient degrees of freedom in the solution to exhibit the onset of chaotic vortex flow that could well lead to vortex bursting. These two cases are studied to observe the behavior of the vortex at high incidence angles. The simulated results are compared with wind-tunnel measurements. The agreement at inboard sections is reasonable for the position and strength of the leading-edge vortex, but outboard it is poor because of the complex transition to disordered vortex flow at the tip. Both the numerical simulation and the experimental measurements show that the flow at $\alpha = 12.5$ deg is unsteady. The computations predict a premature bursting of the vortex at $\alpha = 20$ deg, and the flow is again steady. Author

A86-49028* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ALGEBRAIC GRID GENERATION ABOUT WING-FUSELAGE BODIES

R. E. SMITH (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 471-481. refs

An algebraic procedure for the generation of boundary-fitted grids about wing-fuselage configurations is presented. A wing-fuselage configuration is specified by cross sections and mathematically represented by Coons' patches. A configuration is divided into sections so that several grid blocks that either adjoin

each other or partially overlap each other can be generated. Each grid has six exterior surfaces that map into a computational cube. Grids are first determined on the six boundary surfaces and then in the interior. Grid curves that are on the surface of the configuration are derived from the intersection of planes with the Coons' patch definition. Single-valued functions relating approximate arc lengths along the grid curves to a computational coordinate define the distribution of grid points. The two-boundary technique and transfinite interpolation are used to determine the boundary surface grids that are not on the configuration, and transfinite interpolation with linear blending functions is used to determine the interior grid. Author

A86-49030#

APPLICATION OF A FULL POTENTIAL METHOD TO PRACTICAL PROBLEMS IN SUPERSONIC AIRCRAFT DESIGN AND ANALYSIS

K. B. WALKLEY and G. E. SMITH (DEI-Tech, Inc., Newport News, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 491-501. USAF-supported research. refs

A method based on the conservation form of the full potential equation has been used to analyze realistic aircraft configurations at supersonic speeds. A fighter forebody with and without a canopy and a supersonic cruise wing-body concept have been addressed in the Mach 1.41 to 2.30 speed range. Comparisons of predicted and measured surface pressure distributions and lift and drag for the forebody configurations showed excellent to good correlations although some oscillations in the computed pressures were observed. Good to excellent results for the wing-body configuration were obtained as well. The nonlinear behavior of the pitching moment was well predicted although the magnitudes were somewhat low. These analyses have all been conducted using single-precision arithmetic on a VAX 11/780 computer. Execution times averaged from one-half to three quarters of an hour for the forebody configurations and slightly over four hours for the wing-body. Author

A86-49031#

BOUNDARY LAYER CALCULATION AND VISCOUS-INVISCID COUPLING

A. G. T. CROSS (British Aerospace, PLC, Military Aircraft Div., Brough, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 502-512. Research supported by the Ministry of Defence (Procurement Executive). refs

This paper deals with the calculation of attached and separated flow using turbulent integral boundary layer theory, a law of the wall and wake form of velocity profile and a strong coupling equation based on the combined boundary layer and transpiration velocity equations. Emphasis is placed on the velocity profile and the governing equations which are applicable to both two and three-dimensional flow. Author

A86-49032#

WAKE/BOUNDARY-LAYER INTERACTIONS IN TWO AND THREE DIMENSIONS

L. C. SQUIRE, D. AGORPOULOS, and A. H. KH. MOGHADAM (Cambridge University, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 513-521. Research supported by Cambridge University and British Aerospace, PLC. refs

This paper describes a program of work on the interaction between wakes and boundary layers which occurs on multielement aerofoils in high lift situations. The work has concentrated on the following two aspects: (a) experiments designed to isolate the separate effects of slat shape, gap size, wake strength, pressure gradient and crossflow and (b) the careful evaluation of various numerical schemes for predicting these flows. It is shown that in two-dimensional flow the turbulence levels in the wake and the

pressure gradients on the main aerofoil are the main parameters governing the interaction process and that these effects can be predicted with good accuracy by numerical calculations incorporating either an algebraic stress model or a K-epsilon model. The work on three-dimensional aspects of the interaction has not reached such an advanced stage but a digital system for measuring and recording all the components of the Reynolds stress tensor using a triple hot-wire probe has been developed and used to measure a number of three-dimensional flows. In cases where the flow is quasi-three-dimensional, (that is it resembles the flow over an infinite yawed wing) the numerical calculations can be used to predict the streamwise and crossflow velocities with similar accuracy to that achieved in two dimensions. Author

A86-49033#

ON THE DURATION OF LOW SPEED DYNAMIC STALL

R. A. MCD. GALBRAITH, A. J. NIVEN (Glasgow, University, Scotland), and L. Y. SETO (British Marine Technology, London, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 522-531. Research supported by the Ministry of Defence. refs

The paper considers dynamic stall of aerofoils and, in particular, the duration of the stall once it has been initiated. The stalling process is likened to a transition from a streamlined flow to that of a bluff body where the flow development is governed by the mean flow. It is concluded that the present data favors this transition occurring soon after stall onset and, because of this, there are constant nondimensional time delays associated with the process; independent of reduced frequency/pitch rate and aerofoil shape, etc. Author

A86-49042#

LEADING EDGE VORTEX FLOW OVER A 75 DEGREE-SWEPT DELTA WING EXPERIMENTAL AND COMPUTATIONAL RESULTS

R. CARCAILLET, F. MANIE, D. PAGAN, and J. L. SOLIGNAC (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 589-603. Research supported by the Ministere de la Defense. refs

(ONERA, TP NO. 1986-122)
A detailed experimental investigation of the leading edge vortex flow over a 75 deg-swept, sharp-edged delta wing set at an angle of attack $\alpha = 20$ deg is reported. The investigation was conducted in several ONERA wind tunnels and involved flow field surveys using a five-hole pressure probe and LDV techniques. Reynolds number effects are evidenced, and the structure of the vortical flow regions is discussed; they are shown to be of a nonconical nature. Global and local experimental data is then used to assess the three-dimensional vortex particle method being developed at ONERA. Recent improvements to the method are presented. Various test cases demonstrate its capabilities; in particular, computation of the vortex flow over a 70 deg-swept delta wing at $\alpha = 20$ deg leads to a remarkably good agreement with results obtained from other methods. Author

A86-49043#

FREE-VORTEX FLOW SIMULATION USING A THREE-DIMENSIONAL EULER AERODYNAMIC METHOD

P. RAJ, J. S. SIKORA, and J. M. KEEN (Lockheed-California Co., Burbank) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 604-617. Research supported by the Lockheed-California Independent Research and Development Program and USAF. refs

A computational method based on a finite-volume, multistage Runge-Kutta pseudo-time-stepping algorithm to solve the three-dimensional Euler equations is used to simulate free vortices generated by separation of flow along the edges of swept, slender wings at moderate-to-high angles of attack. The flow is impulsively started and the vortices are automatically captured. Two issues

are specifically addressed: (1) sensitivity of the solutions to artificial viscosity, and (2) effect of grid density on the results. Computed results for a cropped-delta wing, an arrow wing, and a strake-wing-body configuration are correlated with experimental data and, wherever possible, with predictions of other numerical methods. Relatively small changes in the subsonic solutions are noticed with variations in the magnitude of artificial viscosity and grid density, as long as the free vortices are generated along sharp edges. The correlations presented here provide an added measure of confidence in computational simulations using the Euler equations. The present investigation also raises some new issues related to vortex instabilities. Author

A86-49044#

EVALUATION OF PRESSURE DISTRIBUTIONS ON AN AIRCRAFT BY TWO DIFFERENT PANEL METHODS AND COMPARISON WITH EXPERIMENTAL MEASUREMENTS

A. BASTON, M. LUCCHESINI, L. MANFRIANI (Aermacchi S.p.A., Varese, Italy), L. POLITO, and G. LOMBARDI (Pisa, Università, Italy) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 618-628. refs

This paper presents a comparison between the results obtained from a 'first-order singularity' panel program in use at Aermacchi (NLR program) and a program based on Morino's theory developed at the University of Pisa. The comparison is based on a realistic, rather complex fighter aircraft configuration for which extensive wind tunnel data are available; a number of discretized geometry schemes with different degrees of refinement have been used, and an attempt has been made to compare, realistically, the computer usages in terms of time and memory occupation. The results obtained refer to the pressure and load distributions on the fuselage at Mach = 0.7 and on the wing at Mach = 0.5. Author

A86-49045*# Old Dominion Univ., Norfolk, Va.

FINITE-VOLUME AND INTEGRAL-EQUATION TECHNIQUES FOR TRANSONIC AND SUPERSONIC VORTEX-DOMINATED FLOWS

O. A. KANDIL, A. CHUANG, and L.-C. CHU (Old Dominion University, Norfolk, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 629-640. refs

(Contract NAG1-648; NAG1-591)

Two computational techniques are developed to calculate the compressible vortex-dominated flows. The first technique is a finite-volume Euler Solver which uses four-stage Runge-Kutta time stepping with second- and fourth-order dissipation terms. The technique is applied to supersonic conical and three-dimensional flows about sharp- and round-edged delta wings. Attached and separated-flow solutions have been obtained depending on the values of damping coefficients. The second technique is an integral-equation solver of the full potential equation which uses a volume-integral term in addition to the classical surface-integral terms. The technique is applied to transonic three-dimensional flows about sharp-edged delta wings. A hybrid technique which combines the finite-volume and the integral-equation solvers is also presented. Author

A86-49046#

EFFECTS OF SPANWISE BLOWING ON PRESSURE DISTRIBUTION AND LEADING-EDGE VORTEX STABILITY

J. ER-EL and A. SEGNER (Technion - Israel Institute of Technology, Haifa) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 641-650. refs

Spanwise blowing (SWB) effects on the leading-edge vortex trajectory and breakdown, and on the pressure distribution over a 60 deg delta wing/ogive-cylinder body configuration were investigated experimentally in low speed flow. Schlieren pictures through a transparent wing were recorded in addition to pressure

mapping. Flow visualization showed that the interaction of the SWB jets with the surrounding flow and its effects on the vortex stability greatly depended on the proximity of the SWB nozzles to the vortical core of the vortices. Mounting a body over the wing resulted in an increase in the leading-edge suction peak and in its outward displacement, while decreasing the suction over the inboard part of the wing. The overall lift remained equal to that of the wing alone in the linear-lift range of the angle of attack, fell below that of the wing in the nonlinear-lift range, and delayed the wing stall at alpha greater than 30 deg by stabilizing the vortex. SWB also increased the suction peak and decreased the suction over the inboard parts of the wing at the lower angles of attack (alpha less than or equal to 20 deg). At higher angles the effect on the suction peak was decreasing and acting over a narrowing area in the apex region, but the suction over the inboard wing was increasing, so that the overall effect was a fairly constant lift increment in the angle-of-attack range of alpha less than or equal to 25 deg. At higher angles of attack SWB delayed the vortex breakdown and greatly enhanced the lift of the configuration. Author

A86-49049#

ANALYSIS OF STRAKE-SLENDER-WING CONFIGURATIONS USING SLENDER-WING THEORY

J. KRISPIN and H. PORTNOY (Technion - Israel Institute of Technology, Haifa) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 676-680. refs

A theoretical approach for investigating the flow over strake-slender-wing combinations is presented. The method developed consists of a modification of a well-known, slender-wing-theory model, together with the development of an approximate, local solution in the kink region. The theoretical results predicted by the present method permit a rapid, qualitative investigation of the parameters which influence the vortex-flow patterns and the aerodynamic coefficients, within certain limitations and to compare configurations. Quantitatively the calculation results in an overprediction of the forces. Such trends are typical of slender-wing methods. The method could be readily extended to deal with the case of a strake-slender-wing arrangement mounted on a slender fuselage. Author

A86-49050#

ANALYSIS OF THE VORTICAL FLOW AROUND A 60 DEGREE DELTA WING WITH VORTEX FLAP

B. SUNG and J. F. MARCHMAN, III (Virginia Polytechnic Institute and State University, Blacksburg) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 681-691. refs

Subsonic wind tunnel investigation were conducted on a 60 degree swept, flat plate, delta wing with a leading edge vortex flap at a Reynolds number of about 2.14 millions. The optimum flap deflection angles were found where the primary vortex was confined to the leading edge flap. It was also found that the flap deflection could be used to restore a vortex flow from burst vortex condition. A nonlinear vortex lattice code with a new velocity jump formula was developed to predict the aerodynamic characteristics of the delta wing. The current method improved over other nonlinear vortex lattice methods by predicting the pressure distributions, but the suction peak pressures were lower and the location of the suction peaks were predicted farther from the leading edge than the experimental results. Author

A86-49074#

FLOW FIELD STUDY ON A SUPERCRITICAL AIRFOIL USING A PRESSURE PROBE AND A TWO-COMPONENT LASER-DOPPLER-ANEMOMETER

K. A. BUETEFISCH and E. STANEWSKY (DFVLR, Institut fuer Experimentelle Stromungsmechanik, Goettingen, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 911-922. refs

The aim of this study was the investigation of the phenomenon of shock boundary layer interaction on a supercritical airfoil with and without shock-induced separation and a comparison of results obtained by conventional boundary layer probe and a two component Laser Doppler Anemometer. Measurements were made in the 1 x 1 sq m Transonic Wind Tunnel (TWG) of the DFVLR Goettingen on a 250 mm chord model of the airfoil CAST 7/DOAI at a Mach number of 3.6 deg and 4.8 deg. The Reynolds number was $Re = 2.5$ million. Author

A86-49080#

THE ROLE OF FLOW FIELD COMPUTATION IN IMPROVING TURBOMACHINERY

J. DUNHAM (Royal Aircraft Establishment, Farnborough, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 967-980. refs

A historical review is presented of the influence of flow field computation on the development of UK compressors and turbines. The ability to predict meridional flows and later blade surface pressures has led to increasingly successful attempts to tailor aerofoil shapes in such a way as to optimise performance. Once proven, new computer programs have rapidly been put to use by turbomachinery designers in Rolls-Royce and some non-aeronautical firms. The present state of the art of turbomachinery computational fluid dynamics is assessed. Inviscid quasi-two-dimensional methods are dominant, but fully three-dimensional inviscid methods and two-dimensional viscous-inviscid methods are now used for some purposes. Three-dimensional viscous methods are under development and have been tentatively applied. The need for detailed experimental test cases to prove the reliability of these various methods is emphasized. The prospects for future computational developments are discussed. With more and more powerful computers becoming available, one of the problems is the presentation of results to the analyst. Another is the development of mathematical models for unsteady blade-row interactions. The economical representation of viscous effects remains a key difficulty, as it always has been, especially when heat transfer predictions are needed. Author

A86-49098#

INTERSECTION OF AN OBLIQUE SHOCK WAVE WITH A CYLINDRICAL AFTERBODY

G. C. SHEN (Luoyang Dynamics Institute, People's Republic of China) and D. R. PHILPOTT (Hatfield Polytechnic, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1162-1167. Research supported by the Ministry of Defence (Procurement Executive). refs

Surface pressure distributions, oil film and schlieren photographs have been obtained for the intersection of a cylinder by a weak oblique shock wave, (generated by wedges giving flow deflections of 6, 9.5 and 13 deg) in a free stream Mach number of 2.5. The effect of the cylinder nose length and the position of the wedge were investigated. Author

A86-49102#

THE PREDICTION OF LIFT INFERRED FROM DOWNSTREAM VORTICITY MEASUREMENTS

W. SEND (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1190-1200. refs

Attention is given to a novel means of investigating the wakes in wind tunnel tests and predicting lift distributions from downstream vorticity measurements. It is found that two steps of approximation relate the shift in running time to steady and unsteady downstream vorticity as well as to spanwise lift distribution. It is noted that the present method provides integral values in thin and sensitive regions. Comparative measurements of tip shapes and investigation of rotor wakes are the preferred areas of application. K.K.

A86-49103#

METHOD OF ANALYSING DATA ON A SWEEPED WING AIRCRAFT IN FLIGHT

A. BERTELUD and J. OLSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1201-1212. refs

Over a number of years the Aeronautical Research Institute of Sweden, FFA, has operated a swept wing aircraft for aerodynamic investigations. The results from more than 120 flights have been organized in a computerized database where information may be obtained for a number of different flow problems. In the present paper an account is given of the database, its characteristics as well as examples of how it may be used to describe the flow on a swept wing at subsonic Mach numbers. Author

A86-49104*# Texas A&M Univ., College Station.

AN EXPERIMENTAL STUDY OF A THREE LIFTING SURFACE CONFIGURATION

C. OSTOWARI and D. NAIK (Texas A & M University, College Station) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1213-1224. refs (Contract NAG1-344)

The aerodynamic ramifications of utilizing three lifting surfaces as opposed to the conventional or canard lifting configurations have been studied on a theoretical basis by previous researchers. This paper presents an experimental investigation of various configuration modifications for an unyawed typical business jet at a Reynolds number of 1.3 million. The three surface has better lift and high-lift drag characteristics than either the canard or tail-aft configurations, but the cruise drag is more. The induced drag at cruise is highest for the canard and lowest for the tail-aft configuration. The pitching moment characteristics are somewhat between those of the canard and tail-aft configurations. A decrease in gap adversely affects the pitching moment characteristics. A smaller stagger leads to better aerodynamic and stability characteristics. A decrease in span of the forward wing gives better cruise drag and longitudinal stability characteristics, but has adverse effects on high-lift drag. A variation in the incidence angles of either or both the forward and aft wings changes the zero-lift moments of the configuration, while marginally affecting overall lift and drag. At cruise, the lift to drag ratio is highest for the conventional and lowest for the three surface. For high lift conditions, the order is reversed. Author

A86-49105*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

APPLICATIONS OF POTENTIAL THEORY COMPUTATIONS TO TRANSONIC AEROELASTICITY

J. W. EDWARDS (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1225-1242. refs

Unsteady aerodynamic and aeroelastic stability calculations based upon transonic small disturbance (TSD) potential theory

are presented. Results from the two-dimensional XTRAN2L code and the three-dimensional XTRAN3S code are compared with experiment to demonstrate the ability of TSD codes to treat transonic effects. The necessity of nonisentropic corrections to transonic potential theory is demonstrated. Dynamic computational effects resulting from the choice of grid and boundary conditions are illustrated. Unsteady airloads for a number of parameter variations including airfoil shape and thickness, Mach number, frequency, and amplitude are given. Finally, samples of transonic aeroelastic calculations are given. A key observation is the extent to which unsteady transonic airloads calculated by inviscid potential theory may be treated in a locally linear manner. Author

A86-49106#

STEADY AND UNSTEADY INVESTIGATIONS OF SPOILER AND FLAP AERODYNAMICS IN TWO DIMENSIONAL SUBSONIC FLOWS

M. COSTES, A. GRAVELLE, J. J. PHILIPPE (ONERA, Chatillon-sous-Bagneux, France), S. VOGEL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany), and H. TRIEBSTEIN (DFVLR, Goettingen, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1243-1253. (ONERA, TP NO. 1986-101)

An experimental study has been performed in the ONERA F1 pressurized wind tunnel on a 1 m chord supercritical airfoil equipped with a spoiler and a flap in a two-dimensional flow. Both spoiler and flap can be steadily deflected simultaneously and one control surface can then be driven with a harmonic motion, a white noise motion, or a ramp motion for various rise times. Steady and unsteady pressures, lift and moment coefficients depend on Reynolds number, mean steady deflection and frequency. The interaction between the control surfaces is examined. Unsteady pressure time histories for ramp type motions for various rise times and initial deflections are also given. Finally, some comparisons are presented between a theoretical method developed at ONERA and the experimental data for a steady deflected spoiler. Author

A86-49108#

OSCILLATING WINGS AND BODIES WITH FLEXURE IN SUPERSONIC FLOW APPLICATIONS OF HARMONIC POTENTIAL PANEL METHOD

D. D. LIU, P. GARCIA-FOGEDA (Arizona State University, Tempe), and P. C. CHEN IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1270-1284. Army-supported research. refs

The development of the Harmonic Gradient Method (HGM) and the Harmonic Potential Panel (HPP) method for nonplanar wings and bodies in unsteady supersonic flow is presented. They are proved to be accurate and versatile tools for computations of unsteady aerodynamics. According to a consistent formulation, the bases of both methods are now unified. Owing to the Harmonic Potential model, optimal number of panels can be achieved without loss of the computational accuracy. And yet it is least affected by the given Mach number and reduced frequency. Moreover, these methods are completely general in terms of input oscillatory frequencies, mode shapes and body or planform geometries. To validate the HGM/HPP computer codes, various computed results are compared with all known cases. These results demonstrate that the computer codes are attractive in their efficiency and cost-effectiveness for aeroelastic analyses, which suggest immediate industrial applications. Author

A86-49109#

ON THE COMPUTATION OF WING LIFT INTERFERENCE CAUSED BY HIGH BYPASS ENGINES

C. HABERLAND and G. SAUER (Berlin, Technische Universitaet, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1285-1294. DFG-supported research. refs

Wind tunnel investigations with respect to optimization of commercial aircraft reveal that lift reduction due to engine interference can be significantly decreased by optimizing engine position and fan shroud contour. As a numerical approach a 3D-engine singularity method has been developed, which includes a realistic jet model. The quality and applicability of the method was tested by comparing the results (flow field, pressure coefficient, leakage) with those from the previous axisymmetric model. In order to adjust the exit velocity at the fan nozzle to the inlet flow and the fan pressure ratio, the engine singularity model was extended by an additional doublet (stator-) disc. Interference calculations on an actual research wing were performed by means of the axisymmetric engine procedure as a first step. Author

A86-49122*# Texas A&M Univ., College Station.

WING LAMINAR BOUNDARY LAYER IN THE PRESENCE OF A PROPELLER SLIPSTREAM

S. J. MILEY, R. M. HOWARD (Texas A & M University, College Station), and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1413-1420. refs

(Contract NAG1-344)

The effects of a propeller slipstream on the wing laminar boundary layer are being investigated. Hot-wire velocity sensor measurements have been performed in flight and in a wind tunnel. It is shown that the boundary layer cycles between a laminar state and a turbulent state at the propeller blade passage rate. The cyclic length of the turbulent state increases with decreasing laminar stability. Analyses of the time varying velocity profiles show the turbulent state to lie in a transition region between fully laminar and fully turbulent. The observed cyclic boundary layer has characteristics similar to relaminarizing flow and laminar flow with external turbulence. Author

A86-49174

THE PROBLEM OF FLOW PAST A PLANE DELTA WING WITH POWER-LAW INJECTION AT ITS SURFACE [ZADACHA PRO OBTIKANNIA PLOSKOGO TRIKUTNOGO KRILA PRI STEPENEVOMU ZAKONI VDUVU NA IOGO POVERKHNI]

A. M. ANTONOVA and L. I. DZVONIK (Kievskii Gosudarstvennyi Universitet, Kiev, Ukrainian SSR) Akademiia Nauk Ukrain's'koi RSR, Dopovidi, Seriya A Fiziko-Matematichni ta Tekhnichni Nauki (ISSN 0002-3531), April 1986, p. 27-29. In Ukrainian.

The paper is concerned with the nonlinear boundary value problem of hypersonic gas flow around a plane delta wing, with nonzero boundary conditions on the wing surface resulting from intense mass transfer. A mathematical formulation of the boundary value problem is presented and flow characteristics in the injection zone are investigated for the case of power-law injection. V.L.

A86-49245#

TURBULENT TRANSONIC FLOW FOR NACA 0012/RAE 2822 AIRFOILS UNDER BALDWIN-LOMAX MODEL

T. FUJIWARA, Y.-Y. WANG, and Y. OHMORI (Nagoya University, Japan) Nagoya University, Faculty of Engineering, Memoirs (ISSN 0027-7657), vol. 37, no. 2, 1985, p. 203-218. refs

The computation scheme of Beam and Warming (1978) was applied to transonic flows around two-dimensional airfoils NACA 0012 and RAE 2822, taking account of the Baldwin-Lomax (1978) turbulence model. After appropriate grid generation techniques, the calculation successfully led to steady flows containing a shock wave and flow separation, for uniform-flow Mach number 0.75, Reynolds number 6×10^6 to the 6th, and angles of attack 0 to 15

degrees. Note that periodical oscillations were observed at high angles of attack. Author

A86-49441

ON THE MOTION OF SPRAY DROPS IN THE WAKE OF AN AGRICULTURAL AIRCRAFT

M. ATIAS and D. WEIHS (Technion - Israel Institute of Technology, Haifa) Atomisation and Spray Technology (ISSN 0266-3481), vol. 1, 1985, p. 21-36. refs

This paper summarizes results obtained using a mathematical model developed in order to investigate the behaviour of an agricultural airplane wake near the ground and the motion of sprays under the influence of this wake. The model describes the flow field generated following the motion of a pair of concentrated wing-tip vortices near the ground and the motion of evaporating drops in this flow field. As examples for use of this model, the distribution of different initial drop size sprays was investigated as well as the influence of the relative humidity and of changing initial velocity of the drops. Author

A86-49573#

PREDICTION OF GUST LOADINGS AND ALLEVIATION AT TRANSONIC SPEEDS

D. NIXON and K. L. TZUOO (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986. 12 p. refs

(Contract N00167-83-C-0114)

(AIAA PAPER 86-0997)

The transonic indicial theory is used to predict the effect of a gust on an airfoil at transonic speeds. The effect of operating two control surfaces is also modeled by the indicial method. The transonic indicial method is linear in a strained coordinate system and superposition can be used. This allows the effects of an arbitrary gust and control surface deflection to be modeled simply if the indicial responses for the gust and each control surface are known. The computation time is small and, therefore, an optimization technique can be used to determine the best control surface deflections to alleviate the gust loading. Author

A86-49576*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AN ENTROPY CORRECTION METHOD FOR UNSTEADY FULL POTENTIAL FLOWS WITH STRONG SHOCKS

W. WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA), M. M. HAFEZ (California, University, Davis), and S. J. OSHER (California, University, Los Angeles) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 13 p. refs (AIAA PAPER 86-1768)

An entropy correction method for the unsteady full potential equation is presented. The unsteady potential equation is modified to account for entropy jumps across shock waves. The conservative form of the modified equation is solved in generalized coordinates using an implicit, approximate factorization method. A flux-biasing differencing method, which generates the proper amounts of artificial viscosity in supersonic regions, is used to discretize the flow equations in space. Comparisons between the present method and solutions of the Euler equations and between the present method and experimental data are presented. The comparisons show that the present method more accurately models solutions of the Euler equations and experiment than does the isentropic potential formulation. Author

A86-49577#

CALCULATION OF STATIC ELASTIC EFFECTS ON A MODERN HIGH PERFORMANCE FIGHTER AIRCRAFT

P. CAAP and L. ELEMELAND (Saab-Scania AB, Linköping, Sweden) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 14 p. refs (AIAA PAPER 86-1771)

A linear lifting surface method has been used to calculate the static aeroelastic effects on a modern fighter configuration. The complete configuration was modelled. The same aerodynamic and

structural model was used for all loadcases and Mach numbers. A great number of different load cases, with various angle-of-attack, sideslip, and elevator deflection conditions, has to be calculated to define the database describing the aerodynamics of the airplane. Results are given for some asymmetrical cases at subsonic and supersonic speeds. The great importance of including the complete aircraft in the calculations is shown. Results are given which explain the effect of the vertical fin and flexible fuselage. From these results, the steady-state angular velocity at a roll maneuver is calculated. The deformed aircraft at supersonic speed and low altitude in such a maneuver is depicted. Author

A86-49578*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HIGH-ANGLE-OF-ATTACK AERODYNAMICS - LESSONS LEARNED

J. R. CHAMBERS (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 34 p. refs

(AIAA PAPER 86-1774)

Recently, the military and civil technical communities have undertaken numerous studies of the high angle-of-attack aerodynamic characteristics of advanced airplane and missile configurations. The method of approach and the design methodology employed have necessarily been experimental and exploratory in nature, due to the complex nature of separated flows. However, despite the relatively poor definition of many of the key aerodynamic phenomena involved for high-alpha conditions, some generic guidelines for design consideration have been identified. The present paper summarizes some of the more important lessons learned in the area of high angle-of-attack aerodynamics with examples of a number of key concepts and with particular emphasis on high-alpha stability and control characteristics of high performance aircraft. Topics covered in the discussion include the impact of design evolution, forebody flows, control of separated flows, configuration effects, aerodynamic controls, wind-tunnel flight correlation, and recent NASA research activities. Author

A86-49579*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

FLOWFIELD SURVEY OVER A 75 DEG SWEEPED DELTA WING AT AN ANGLE OF ATTACK OF 20.5 DEG

S. O. KJELGAARD, W. L. SELLERS, III, and R. P. WESTON (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 11 p. refs

(AIAA PAPER 86-1775)

An experimental investigation of the flowfield over a 75 deg swept delta wing at an angle of attack of 20.5 deg has been conducted. The data include pitot pressure surveys and two types of flow visualization. Surface and flowfield visualization data were obtained at Reynolds number, R_n , ranging from 0.5 to 2.0 million in increments of 0.25 million. Detailed pitot pressure surveys were made at five longitudinal stations at $R_n = 0.5$, 1.0, and 1.5 million in both the primary and secondary vortices. The results indicate that Reynolds number has only a minor effect on the global structure of the flowfield in the Reynolds number range that was investigated. The boundary layer transitions from laminar to turbulent at the trailing edge of the wing at $R_n = 1.0 \times 10$ to the 6th, and the transition moves forward to $x/L = 0.4$ at $R_n = 2.0 \times 10$ to the 6th. The positions of the primary vortex cores are insensitive to Reynolds number in this range; however, the lateral position of the secondary vortex core moves outboard aft of the region where the boundary layer transitions from laminar to turbulent. Author

A86-49580*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ROTOR TIP VORTEX GEOMETRY MEASUREMENTS USING THE WIDE-FIELD SHADOWGRAPH TECHNIQUE

T. R. NORMAN and J. S. LIGHT (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 14 p. refs (AIAA PAPER 86-1780)

Rotor tip vortex geometry data have been acquired using the wide-field shadowgraph technique. Shadowgraphs were taken of the wakes of two model main-rotor systems in hover. These shadowgraphs provided detailed tip vortex trajectories from which axial and radial vortex coordinates were measured. Using these coordinates, prescribed-wake parameters were determined and input into a hover-performance prediction code. The resultant predictions were compared with experimental performance data to help assess the capabilities of this code. Another result of the experimental work was the development of a method to predict the visibility of rotor tip vortices on shadowgraphs. Using this method, the ability of the shadowgraph technique to visualize tip vortices in the rotor wake was quantified. Author

A86-49581#

THREE-DIMENSIONAL TRANSONIC FLOW COMPUTATIONS ON SIMPLE SKEWED GRIDS

G. E. CHMIELEWSKI (McDonnell Douglas Corp., Saint Louis, MO) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 12 p. Research supported by the McDonnell Douglas Independent Research and Development Program. refs (AIAA PAPER 86-1794)

This paper describes a finite-difference method that uses a simple grid, generally skewed in all three coordinate directions, to compute inviscid transonic flowfields about wing-alone and (rudimentary) wing/body configurations. Calculations are based on the quasilinear form of the full potential equation. The computational grid is not body-conforming and thus requires application of an interpolation/extrapolation scheme at embedded configuration surfaces to enforce exact boundary conditions. A hybrid combination of two surface-boundary schemes is used. Author

A86-49582#

TRANSONIC WAVE DRAG ESTIMATION AND OPTIMIZATION USING THE NONLINEAR AREA RULE

N. MALMUTH (Rockwell International Science Center, Thousand Oaks, CA), C. C. WU (California, University, Los Angeles), and J. D. COLE (Rensselaer Polytechnic Institute, Troy, NY) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 13 p. Research supported by the Rockwell International Corp. refs (AIAA PAPER 86-1798)

Nonlinear area ruling procedures based on the transonic slender body and lift-dominated theories are described as a means of providing low-cost wave drag estimates and optima for basepoint definition. The computational implementation is capable of accurately predicting drag rise of realistic configurations and shows applicability to moderate supersonic Mach numbers. An analogy between the zero lift and lift-dominated case establishes a basis for sizeable wave drag due to lift reduction through planform and sectional shaping. Results illustrating potential benefits are shown for a fighter configuration in which a small movement of the maximum thickness location of the equivalent body of revolution with volume fixed gives a fourfold reduction in zero-lift wave drag. This benefit can be translated into similar reductions in transonic wave drag due to lift. Author

A86-49584#

TIME-AVERAGED SUBSONIC PROPELLER FLOWFIELD CALCULATIONS

W. O. VALAREZO and J. L. HESS (Douglas Aircraft Co., Long Beach, CA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 6 p. refs (AIAA PAPER 86-1807)

An existing surface panel method capable of calculating detailed subsonic flow about isolated propeller/nacelle configurations has been generalized to compute the aerodynamic interference between an installed turboprop powerplant and the remainder of the aircraft. Fluctuating velocity fields resulting from the rotating propeller are time-averaged and mutual interference is obtained as an equivalent steady flow. Computed propeller performance shows good agreement with experiment for advanced propeller designs and computed propeller-airframe interference effects show accuracy and detail previously unobtainable. Author

A86-49585*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PLUME CHARACTERISTICS OF SINGLE-STREAM AND DUAL-FLOW CONVENTIONAL AND INVERTED-PROFILE NOZZLES AT EQUAL THRUST

U. H. VON GLAHN and J. H. GOODYKOONTZ (NASA, Lewis Research Center, Cleveland, OH) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 38 p. Previously announced in STAR as N86-26285. refs (AIAA PAPER 86-1809)

The plume velocity and temperature decay rates of single-stream, conventional dual-flow and inverted-profile dual-flow nozzles are compared at equal values of ideal thrust over a wide range of flow conditions. The comparisons are made in terms of constant velocity and temperature contour maps. The results show that both dual-flow nozzle types have much greater plume velocity and temperature decay rates than those of equivalent thrust single-stream nozzles when the respective secondary flows were at ambient temperature. With hot secondary flows, the inverted-profile dual-flow plumes decayed significantly faster than those of single-stream nozzles; however, the decay rates for the conventional dual-flow streams were about the same as those for the single-stream nozzles. Consequently, with hot secondary flows, the inverted-profile dual-flow plumes decayed much faster than the conventional dual-flow plumes at equal thrust. Author

A86-49586#

CALCULATION OF 2-D UNSTEADY TRANSONIC FULL POTENTIAL FLOW ABOUT OSCILLATING AIRFOILS BY TWO COMPLEMENTARY APPROACHES

H. SCHIPPERS and M. H. L. HOUNJET (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 10 p. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs (AIAA PAPER 86-1821)

Results of two-dimensional unsteady transonic flow calculations for AGARD standard aeroelastic configurations are presented, which have been obtained from NLR's numerical methods for the solution of the unsteady full potential equation. Two complementary methods have been applied to oscillating transonic flow about thick blunt-nosed airfoils: (1) the time-integration TULIPS method, and (2) the time-linearized FTRANC method. The calculations have been performed for the subsonic and transonic flow about the NACA 64A010 (Ames) airfoil and for the flow about the supercritical NLR 7301 airfoil, both undergoing sinusoidal pitching oscillations. The results of both methods are extensively compared. Author

A86-49588*# Boeing Military Airplane Development, Seattle, Wash.

PN/S CALCULATIONS FOR A FIGHTER W/F AT HIGH-LIFT YAW CONDITIONS

J. C. WAI, G. BLOM, H. YOSHIHARA (Boeing Military Airplane Co., Seattle, WA), and D. CHAUSSEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 9 p. refs (AIAA PAPER 86-1829)

The NASA/Ames parabolized Navier/Stokes computer code was used to calculate the turbulent flow over the wing/fuselage for a generic fighter at $M = 2.2$. 18 deg angle-of-attack, and 0 and 5 deg yaw. Good test/theory agreement was achieved in the zero yaw case. No test data were available for the yaw case.

Author

A86-49589#

NAVIER-STOKES SIMULATION OF TRANSONIC FLOW OVER WING-FUSELAGE COMBINATIONS

K. FUJII (National Aerospace Laboratory, Chofu, Japan) and S. OYASHI (Tokyo, University, Japan) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 12 p. refs

(AIAA PAPER 86-1831)

Viscous transonic flow-field simulations over wing-fuselage combinations are carried out using three-dimensional 'Reynolds-averaged' Navier-Stokes equations. Obayashi and Kuwahara's (1985) 'LU-ADI' factorization scheme, which has been developed and improved by the present authors, is used for this study with an implementation of new nonlinear smoothing terms. The computations are done for two kinds of body geometries; one is a modified ONERA M-5 wing-fuselage combination and the other is a practical wing-fuselage combination, called 'W-18', which was designed for the transonic transportation aircraft. The computed results reveal the effect of the existence of the fuselage near the junction of wing and fuselage. Each computation currently requires several hours of computer time (which is, however, quite reasonable when considering the number of the grid points to be used for this study). The results indicate that the application of the present Navier-Stokes solution code to the complete aircraft geometries is quite promising.

Author

A86-49590*# Vigyan Research Associates, Inc., Hampton, Va.
A NEW, IMPROVED METHOD FOR SEPARATING TURBULENT BOUNDARY LAYER FOR AERODYNAMIC PERFORMANCE PREDICTION OF TRAILING EDGE STALL AIRFOILS

S. GORADIA (Vigyan Research Associates, Inc., Hampton, VA) and H. L. MORGAN, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 15 p. refs (AIAA PAPER 86-1832)

A method based on integral techniques is presented to determine the turbulent separation location and separation pressure for trailing edge stall airfoils exhibiting extensive separated flow regions during prestall and poststall conditions. The method and experimental laser velocimetry data in the turbulence amplification region are used to establish a relationship between fluctuating velocity components and mean velocity in the boundary layer. The method is demonstrated for symmetrical, cambered, conventional and supercritical airfoils in the 5-to-21-percent thickness ratio range, and over a Reynolds number range of 2 to 22 million. Good agreement with experimental data is found, and the method is used in conjunction with the NASA Multi-Component Airfoil Computer Program to predict maximum L/D ratios and maximum section/lift coefficients.

R.R.

A86-49591#

VALIDATION OF A FULL POTENTIAL METHOD FOR COMBINED YAW AND ANGLE OF ATTACK

K.-Y. SZEMA and V. SHANKAR (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 11 p. refs (AIAA PAPER 86-1834)

A supersonic implicit marching code based on a full potential equation (known as SIMP code) has been applied to a variety of complex configurations at various free-stream Mach numbers, angles of attack and side-slip conditions. A conservative switching scheme is employed to transition from the supersonic marching procedure to a subsonic relaxation algorithm and vice versa for treatment of embedded subsonic zones. An implicit approximate factorization scheme is implemented. The code is shown to be efficient, robust and easy to use. The computed results for combined yaw and angles of attack are in very good agreement with available experimental data.

Author

A86-49592#

VORTEX INFLUENCE ON OSCILLATING AIRFOIL AT HIGH ANGLE-OF-ATTACK

D. FAVIER, C. MARESCA, C. BARBI (Aix-Marseille II, Universite, Marseille, France), and A. CASTEX AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 12 p. Sponsorship: Service Technique des Programmes Aeronautiques. refs

(Contract STPA-84-95-005)

(AIAA PAPER 86-1837)

The influence of a streamwise vortical flow on an oscillating airfoil is investigated in a low subsonic wind-tunnel. It constitutes a limiting case of more complex practical flow configurations encountered, for instance, on a rotating helicopter blade section interacting with the vortical wakes generated upstream by the blade tips. The present experimental simulation is realized by means of a semispan airfoil generating a tip vortex convected downstream and near the lower side of a second airfoil, which spans the entire test section and oscillates in force and aft-motion. Steady and unsteady behaviors are obtained from lift, drag, and pitching moment measurements, and chordwise pressure and skin friction distributions performed on the oscillating airfoil. Particular attention is paid to the interaction effect of the lifting surface on the path and strength of the impinging vortex.

Author

A86-49593#

LOW-SPEED AERODYNAMICS OF APEX FENCES ON A TAILLESS DELTA CONFIGURATION

K. D. HOFFLER, D. M. RAO (Vigyan Research Associates, Inc., Hampton, VA), and M. C. FRASSINELLI (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 10 p.

(Contract MIPR-FY-1456-85-00032)

(AIAA PAPER 86-1838)

Apex fences are highly swept, upper-surface spoiler-like surfaces hinged at the leading edges of a delta wing. The fences are deployed vertically to generate a strong pair of counter-rotating vortices at low angles of attack when the main-wing vortex system is weak. The intense suction induced by the fence vortices on the wing apex area creates a nose-up moment which, in conjunction with trailing-edge flaps, will enhance the trimmed-lift capability thus reducing landing speed. Conversely, at high angles of attack, when the basic delta wing apex is highly loaded, the fences reduce the apex lift resulting in pitch-down acceleration for a rapid return to normal flight attitude. These hypothesized characteristics of the apex fence concept were validated through low-speed tunnel experiments on a 60-deg delta wing configuration using flow visualization techniques, upper surface pressure surveys, and balance measurements. This paper presents selected results of the investigation indicating the quantitative benefits realizable by the application of apex fences to tailless delta aircraft.

Author

A86-49625*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY RESULTS OF UNSTEADY BLADE SURFACE PRESSURE MEASUREMENTS FOR THE SR-3 PROPELLER

L. J. HEIDELBERG and B. J. CLARK (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 25 p. Previously announced in STAR as N86-27213. refs (AIAA PAPER 86-1893)

Unsteady blade surface pressures were measured on an advanced, highly swept propeller known as SR-3. These measurements were obtained because the unsteady aerodynamics of these highly loaded transonic blades is important to noise generation and aeroelastic response. Specifically, the response to periodic angle-of-attack change was measured for both two- and eight-bladed configurations over a range of flight Mach numbers from 0.4 to 0.85. The periodic angle-of-attack change was obtained by placing the propeller axis at angles up to 4 deg to the flow. Most of the results are presented in terms of the unsteady pressure coefficient variation with Mach number. Both cascade and Mach number effects were largest on the suction surface near the leading edge. The results of a three-dimensional Euler code applied in a quasi-steady fashion were compared to measured data at the reduced frequency of 0.1 and showed relatively poor agreement. Pressure waveforms are shown that suggest shock phenomena may play an important part in the unsteady pressure response at some blade locations. Author

A86-49676# SOUNDING A HAPPY NOTE FOR LIFT

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Aug. 1986, p. 10, 11.

The use of sound is suggested as a way to eliminate vortex generators, as well as flaps and slats used on the aircraft wings to control the airflow. However, wind-tunnel tests in which aviation airfoil was excited by sound transducers in the tunnel wall above, did not reveal existence of relationships between sound frequency and intensity (and airfoil geometry) and flow speed. Possible ways of exciting instability waves are discussed, including a narrow 'flap ribbon' laid spanwise along a stretch of wing to eliminate flaps and slats, or applied only at spots where stalls first occur. Vibrating the skin directly is also considered as a technique for using sound to control compressor stall. I.S.

A86-49801# TRAPPING OF A FREE VORTEX BY AIRFOILS WITH SURFACE SUCTION

C.-Y. CHOW, M.-K. HUANG (Colorado, University, Boulder), and C.-L. CHEN AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1217, 1218. Previously cited in issue 07, p. 846, Accession no. A85-19755. (Contract AF-AFOSR-81-0037)

A86-49802*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

RECENT DEVELOPMENTS IN ROTARY-WING AERODYNAMIC THEORY

W. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1219-1244. refs

Current progress in the computational analysis of rotary-wing flowfields is surveyed, and some typical results are presented in graphs. Topics examined include potential theory, rotating coordinate systems, lifting-surface theory (moving singularity, fixed wing, and rotary wing), panel methods (surface singularity representations, integral equations, and compressible flows), transonic theory (the small-disturbance equation), wake analysis (hovering rotor-wake models and transonic blade-vortex interaction), limitations on computational aerodynamics, and viscous-flow methods (dynamic-stall theories and lifting-line theory). It is suggested that the present algorithms and advanced computers make it possible to begin working toward the ultimate goal of turbulent Navier-Stokes calculations for an entire rotorcraft. T.K.

A86-49803*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AIRFOIL TRAILING-EDGE FLOW MEASUREMENTS

T. F. BROOKS, M. A. MARCOLINI (NASA, Langley Research Center, Hampton, VA), and D. S. POPE (Kentron International, Inc., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1245-1251. Previously cited in issue 01, p. 2, Accession no. A85-10831. refs

A86-49804*# Science Applications International Corp., Princeton, N.J.

PARABOLIZED NAVIER-STOKES ANALYSIS OF THREE-DIMENSIONAL SUPERSONIC AND SUBSONIC JET MIXING PROBLEMS

S. M. DASH, D. E. WOLF, and N. SINHA (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1252, 1253. Previously cited in issue 17, p. 2423, Accession no. A84-37951. refs (Contract NAS1-16535)

A86-49807# PASSIVE CONTROL OF JETS WITH INDETERMINATE ORIGINS

R. W. WLEZIEN and V. KIBENS (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1263-1270. Previously cited in issue 01, p. 2, Accession no. A85-10852. refs (Contract F49620-83-C-0048)

A86-49823# COMPUTATION OF THE POTENTIAL FLOW OVER AIRFOILS WITH CUSPED OR THIN TRAILING EDGES

P. L. ARDONCEAU (Ecole Nationale Supérieure de Mécanique et d'Aérotechnique, Poitiers, France) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1375-1377. refs

A technique for computing the two-dimensional potential flowfield around airfoils with small trailing-edge angles or cusped trailing edges is developed in the context of the method of singularities. The airfoil geometry is modified by means of a simple conformal mapping prior to computation using a basic code, and the results are then transposed to the physical plane via direct (Joukowski) transformation. Results for a NACA 65012 airfoil are presented in tables and graphs and shown to be in better agreement with the exact solutions (Schlichting and Truckenbrodt, 1967) than those obtained using a conventional singularity method. T.K.

A86-49824# CANCELLATION ZONE IN SUPERSONIC LIFTING WING THEORY

A. SANZ (Madrid, Universidad Politécnica, Spain) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1377, 1378.

The linear-theory formulation of Evvard (1950) for the perturbation imposed at supersonic velocity by a thin lifting wing of arbitrary planform on a point located on the wing plane and within the planform is compared analytically with the formulation of Krasilshchikova (1956 and 1982) for points both on and above the wing plane. The Evvard approach is generalized to the case studied by Krasilshchikova and shown to give accurate cancellation-zone results (at least for educational purposes) without inversion of the integral equation and double integration. T.K.

A86-49825*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

TRANSONIC AIRFOIL CALCULATIONS INCLUDING WIND TUNNEL WALL-INTERFERENCE EFFECTS

L. S. KING and D. A. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1378-1380. refs

The results of Reynolds-averaged time-dependent inviscid and turbulent compressible Navier-Stokes computations using the implicit finite-difference approach of Steger (1978), modified by

incorporating a pressure boundary condition, (PBC) to account for wall interference are compared with experimental data on a NACA 64A010 airfoil (Johnson and Bachalo, 1980) in graphs and briefly characterized. The computational approach is the same as that used by King and Johnson (1980), but a 137×50 mesh is used instead of a 97×35 mesh, and special care is taken in resolving the nose, shock, and trailing-edge regions. Imposition of PBC is shown to improve significantly the accuracy of the computations for the flowfield on the upper surface of the airfoil, shifting the shock forward to its experimentally measured position in the case of turbulent flow. The failure of the method, even with PBC, to match the experimental shock location in the case of a flow with a separation bubble is attributed to inadequacies in the algebraic turbulence model employed (Baldwin and Lomax, 1978). T.K.

A86-50269* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

LAMINAR FLOW RESEARCH APPLICABLE TO SUBSONIC AIRCRAFT

J. N. HEFNER and R. D. WAGNER (NASA, Langley Research Center, Hampton, VA) International Symposium on Aeronautical Science and Technology of Indonesia, Djakarta, Indonesia, June 24-27, 1986, Paper. 14 p. refs

Since the beginning of the NASA Aircraft Energy Efficiency (ACEE) program in 1976, significant progress has been made in the development of laminar flow technology for general aviation, commuter, and transport aircraft. Exploitation of new materials, fabrication methods, analysis techniques, and design concepts is providing convincing evidence that practical laminar flow control (LFC) systems for these future subsonic aircraft could become a reality. Program studies indicate that extensive laminar flow might be achieved on small transports with natural laminar flow (NLF) wings and larger transports with hybrid laminar flow (i.e., leading-edge suction on an NLF type of wing). This paper presents an overview of these laminar flow technology developments and describes future efforts in a broadened NASA program to explore the potential and to evaluate the practicality of different laminar flow concepts for commercial transports. Author

N86-31531* Wichita State Univ., Kans.

WEIGHT ESTIMATION TECHNIQUES FOR COMPOSITE AIRPLANES IN GENERAL AVIATION INDUSTRY

T. PARAMASIVAM, W. J. HORN, and J. RITTER Sep. 1986 89 p

(Contract NAG1-452)

(NASA-CR-178163; NAS 1.26:178163; AR-86-1) Avail: NTIS HC A05/MF A01 CSCL 01C

Currently available weight estimation methods for general aviation airplanes were investigated. New equations with explicit material properties were developed for the weight estimation of aircraft components such as wing, fuselage and empennage. Regression analysis was applied to the basic equations for a data base of twelve airplanes to determine the coefficients. The resulting equations can be used to predict the component weights of either metallic or composite airplanes. Author

N86-31532* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

LOW-SPEED AERODYNAMIC CHARACTERISTICS OF A 1/8-SCALE X-29A AIRPLANE MODEL AT HIGH ANGLES OF ATTACK AND SIDESLIP

R. D. WHIPPLE and J. L. RICKET (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.) Sep. 1986 289 p

(NASA-TM-87722; L-15919; NAS 1.15:87722) Avail: NTIS HC A13/MF A01 CSCL 01A

A 1/8-scale model of the X-29A airplane was tested in the Ames 12-Foot Pressure Wind Tunnel at a Mach number of 0.20 and Reynolds numbers of 0.13×10^6 to the 6th power to 2.00×10^6 to the 6th power based on a fuselage forebody depth of 0.4 ft. For the test series presented herein, the angle of attack ranged from 40 deg. to 90 deg. and the angle of sideslip ranged from -10 deg. to 30 deg. for the erect attitude. Tests with the model

inverted covered angles of attack from -40 deg. to -90 deg. and angles of sideslip from -30 deg. to 10 deg. Data were obtained for the basic design and for several forebody strakes. An alternate forebody design was also tested. The results provided information for selection of forebody strakes for compensation of Reynolds number effect on the 1/25-scale free-spinning model tested in the Langley Spin Tunnel.

Author

N86-31535* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ATRAN3S: AN UNSTEADY TRANSONIC CODE FOR CLEAN WINGS

G. P. GURUSWAMY (Informatics General Corp., Palo Alto, Calif.), P. M. GOORJIAN, and F. J. MERRITT Dec. 1985 53 p (NASA-TM-86783; A-85359; NAS 1.15:86783) Avail: NTIS HC A04/MF A01 CSCL 01A

The development and applications of the unsteady transonic code ATRAN3S for clean wings are discussed. Explanations of the unsteady, transonic small-disturbance aerodynamic equations that are used and their solution procedures are discussed. A detailed user's guide, along with input and output for a sample case, is given. Author

N86-31536* Hamilton Standard, Windsor Locks, Conn.

SYSTEM DESIGN AND INTEGRATION OF THE LARGE-SCALE ADVANCED PROP-FAN

B. P. HUTH Aug. 1984 97 p

(Contract NAS3-23051)

(NASA-CR-174789; NAS 1.26:174789; HSER-9333) Avail: NTIS HC A05/MF A01 CSCL 01A

In recent years, considerable attention has been directed toward improving aircraft fuel consumption. Studies have shown that blades with thin airfoils and aerodynamic sweep extend the inherent efficiency advantage that turboprop propulsion systems have demonstrated to the higher speed to today's aircraft. Hamilton Standard has designed a 9-foot diameter single-rotation Prop-Fan. It will test the hardware on a static test stand, in low speed and high speed wind tunnels and on a research aircraft. The major objective of this testing is to establish the structural integrity of large scale Prop-Fans of advanced construction, in addition to the evaluation of aerodynamic performance and the aeroacoustic design. The coordination efforts performed to ensure smooth operation and assembly of the Prop-Fan are summarized. A summary of the loads used to size the system components, the methodology used to establish material allowables and a review of the key analytical results are given. Author

N86-31539* Naval Postgraduate School, Monterey, Calif.

DEVELOPMENT OF A DATA ACQUISITION SYSTEM TO AID IN THE AERODYNAMIC STUDY OF VARIOUS HELICOPTER CONFIGURATIONS M.S. Thesis

P. A. WITT Mar. 1986 101 p

(AD-A167717) Avail: NTIS HC A06/MF A01 CSCL 14B

This thesis developed a data acquisition system to be used in conjunction with the $3.5' \times 5.0'$ low speed wind tunnel at the Naval Postgraduate School. Interactive graphic programs were developed to aid in data acquisition and analysis. In addition, the internal balance was redesigned to correct problems encountered with the drag component. The balance was also instrumented to record the pitch and yaw moment components. A calibration rig was designed and constructed in order to evaluate the interactions to the different components. The equipment used and computer programs developed for data acquisition and analysis were adequate. However, balance calibration revealed problems with the calibration rig and location of the roll component strain gage. Both of these problems will have to be corrected before accurate readings can be expected from this balance design.

Author (GRA)

02 AERODYNAMICS

N86-31541# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

COMPUTATIONS OF SEPARATED SUBSONIC AND TRANSONIC FLOW ABOUT AIRFOILS IN UNSTEADY MOTION

R. HOUWINK 17 Dec. 1984 14 p Presented at 3rd Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, Calif., 21-24 Jan. 1985

(Contract NIVR-1994)

(NLR-MP-84094-U; B8664045; ETN-86-97666) Avail: NTIS HC A02/MF A01

Results of unsteady separated flow computations using the LTRAN2-NLR code (low-frequency transonic small perturbation theory) coupled in strong interaction with Green's lag-entrainment method for a steady turbulent boundary layer are presented. Computations of shock-induced separation were carried out for a supercritical airfoil oscillating in pitch and for the NACA 0012 airfoil at a transient change of angle of attack. Subsonic separated flow was computed for the ONERA RA.16.SC1 airfoil with oscillating spoiler. The results are correlated with experimental data to investigate the applicability of the code. ESA

N86-31542# European Space Agency, Paris (France).

DESIGN OF A BASIC PROFILE FOR A SLIGHTLY SWEEP WING. PART 2: EXPERIMENTAL INVESTIGATION ON THE AIRFOIL DFVLR-W1 IN THE BRUNSWICK TRANSONIC WIND TUNNEL (TWB)

G. WICHMANN Sep. 1985 64 p Original language document was announced as N85-27833

(ESA-TT-916-PT-2; DFVLR-FB-85-01-PT-2; ETN-86-97569) Avail: NTIS HC A054/MF A01; original German version available from DFVLR, Cologne, West Germany DM 19.50

The airfoil DFVLR-W1 was investigated in a transonic wind tunnel at free transition in the Mach number range between 0.5 and 0.81, at a Reynolds number 6 million. The influence of different locations of transition fixing was investigated. Results are presented as aerodynamic coefficients, airfoil performance boundaries, and pressure distributions. It is shown that the design requirements are met by the airfoil. A comparison with theoretical results indicates the applicability of the computer codes are used in the design process. ESA

N86-31543# European Space Agency, Paris (France).

AERODYNAMIC DESIGN METHODS FOR MODERN TRANSPORT AIRCRAFT

H. SOBIECZKY Aug. 1985 82 p Original language document was announced as N85-27838

(ESA-TT-923; DFVLR-FB-85-05; ETN-86-97571) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne, West Germany DM 23

A concept to obtain shock free transonic flows for design aerodynamics of aircraft and turbomachinery is outlined. The method of elliptic continuation or method of fictitious gas represents a starting point for a number of operational computational procedures to obtain supercritical airfoil and wings. Design examples illustrate the value of shock free configuration for aerodynamic efficiency enhancement. The application of supercritical flow in aerodynamic concepts is mentioned. ESA

N86-32390 Virginia Polytechnic Inst. and State Univ., Blacksburg.

ASPECT RATIO EFFECTS ON WINGS AT LOW REYNOLDS NUMBERS Ph.D. Thesis

A. A. ABTAHI 1985 194 p

Avail: Univ. Microfilms Order No. DA8600358

The effect of the aspect ratio on the performance of wings at chord based Reynolds numbers in the range from 50,000 to 500,000 was studied. The methods used for measurement were the strain gauge method, the momentum deficit method, and the surface pressure integration method. A computer program for the solution of flow over a 2-D airfoil was used to computationally determine lift, drag, and pitching moment behavior. This program uses a panel method calculation to determine the inviscid flowfield which serves as an input for a boundary layer circulation. After

the displacement thickness is determined by the boundary layer calculations it is added to the airfoil shape to give new displacement body and the procedure is repeated. The computational results for lift agree well with the experimental data as long as a high Reynolds number was chosen. This indicated that the theoretical model is inadequate to cope with the phenomena occurring at low Reynolds. Agreement was adequate for drag results but pitching moment results showed poor agreement with experimental data.

Dissert. Abstr.

N86-32392*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

TRANSONIC NAVIER-STOKES WING SOLUTIONS USING A ZONAL APPROACH. PART 2: HIGH ANGLE-OF-ATTACK SIMULATION

N. M. CHADERJIAN Apr. 1986 12 p

(NASA-TM-88248-PT-2; A-86222; NAS 1.15:88248-PT-2) Avail: NTIS HC A02/MF A01 CSCL 01A

A computer code is under development whereby the thin-layer Reynolds-averaged Navier-Stokes equations are to be applied to realistic fighter-aircraft configurations. This transonic Navier-Stokes code (TNS) utilizes a zonal approach in order to treat complex geometries and satisfy in-core computer memory constraints. The zonal approach has been applied to isolated wing geometries in order to facilitate code development. Part 1 of this paper addresses the TNS finite-difference algorithm, zonal methodology, and code validation with experimental data. Part 2 of this paper addresses some numerical issues such as code robustness, efficiency, and accuracy at high angles of attack. Special free-stream-preserving metrics proved an effective way to treat H-mesh singularities over a large range of severe flow conditions, including strong leading-edge flow gradients, massive shock-induced separation, and stall. Furthermore, lift and drag coefficients have been computed for a wing up through CLmax. Numerical oil flow patterns and particle trajectories are presented both for subcritical and transonic flow. These flow simulations are rich with complex separated flow physics and demonstrate the efficiency and robustness of the zonal approach. Author

N86-32393# National Aeronautical Lab., Bangalore (India). Systems Engineering Div.

A LOW SPEED TUNNEL SEMI-FREE DYNAMIC FLYING STUDY OF THE HIGH ANGLE OF ATTACK PITCH DERIVATIVES OF HF-24 USING MLE PROCEDURE

S. BALAKRISHNA, T. NIRANJANA, and S. R. RAJAN Aug. 1986 57 p

(NAL-TRM-SE-8603) Avail: NTIS HC A04/MF A01

The high angle of attack pitch stability and control derivatives of a 1/13 model of the HF-24 are generated using a semi-free flying technique. The model is similarity scaled and is flown in a single degree of freedom with a pitch gimble at its center of gravity. The fully instrumented model with its servoed elevator is initially trimmed to the desired angle of attack and is disturbed by a doublet elevator pulse. The model responses are analyzed using a Maximum Likelihood parameter estimation procedure. The results indicate that the semi-free dynamic flying and analysis of the associated motion responses using inertial sensors can provide derivative data which compare well with derivatives generated by traditional methods in wind tunnels. Static stability, pitch damping, control derivatives with the trim data are presented as functions of angle of attack from -10 deg to +25 deg with flaps set at -10, 0, 10, 20 and 30 deg and side slip settings of -10, 0 and 10 deg. The capability of semi-free flying to generate high angle of attack pitch derivatives is demonstrated. Author

N86-32408# Dynetics, Inc., Huntsville, Ala.

AERODYNAMICS OF AIRCRAFT AFTERBODY: REPORT OF THE WORKING GROUP ON AERODYNAMICS OF AIRCRAFT AFTERBODY

1986 348 p

(AGARD-AR-226) Avail: NTIS HC A15/MF A01

Aircraft afterbody design is still one of the most critical problems for industry, especially in fighter aircraft development. The flow

around the rear part of the fuselage is characterized by the simultaneous occurrence of interfering physical phenomena such as thick turbulent boundary layers, viscous flow separation, hot jet interference at the base and the boat tail, and jet plume expansion in three-dimensional transonic and supersonic flow. Even experimental techniques hardly fulfill requirements for correct wind tunnel simulation of all effects. Drag prediction and drag minimization procedures for complex configurations are strongly dependent on the reliability of numerical and experimental flowfield simulation. This publication reports on the progress which has been made by AGARD-FDP Working Group WG08, established to evaluate the state-of-the-art in experimental and computational techniques for aircraft afterbodies. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A86-47293

COMPARISON OF PUBLISHED HEMP AND NATURAL LIGHTNING ON THE SURFACE OF AN AIRCRAFT

R. L. GARDNER, L. BAKER, J. L. GILBERT (Mission Research Corp., Albuquerque, NM), C. E. BAUM, and D. J. ANDERSON (USAF, Weapons Laboratory, Kirtland AFB, NM) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 1-8. refs

The differences between the electromagnetic environment associated with HEMP and that associated with natural lightning are assessed via comparison of the charges and changes taking place on the surfaces of various simple aircraft-like geometries. Exposure to HEMP which is essentially guaranteed in the case of military aircraft at war, causes indirect damage to electronic systems, whereas lightning (though less likely) directly damages the aircraft. Below 1 MHz, lightning dominates and above 10 MHz, HEMP dominates; between these two limits, either may dominate, depending on the details of the aircraft. K.K.

A86-47299

LOCATION OF LIGHTNING STROKES ON AIRCRAFT IN STORM FIELD WITH MEASURED ELECTRICAL, MICROPHYSICAL AND DYNAMICAL PROPERTIES

J. F. GAYET, C. DUROURE, R. G. SOULAGE (Clermont-Ferrand II, Université, France), and P. LAROCHE (ONERA, Chatillon-sous-Bagneux, France) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 67-70. refs
(Contract DRET-83-308; DRET-84-34-001)

The results of microphysical, dynamical, and electrical measurements of the characteristics of clouds when the Transall 04 plane was struck by lightning during the Landes-Fronts 1984 experiment (Laroche et al., 1985) are presented. The measurements were carried out during cloud penetrations between +3 and -20°C. They concern the size spectrum of cloud droplets and drops between 3 and 4500 microns the size spectrum and features of ice crystals between 50 and 6500 microns, the liquid-water content of the cloud, and its vertical velocity. The results show that the striking of the plane occurred in particular regions and stages of growth of the clouds. Author

A86-47332

FIELD OBSERVATIONS OF AIRCRAFT CHARGING IN CONVECTIVE CLOUDS

B. GARDINER, J. HALLETT (Nevada, University, Reno), and C. P. R. SAUNDERS (University of Manchester Institute of Science and Technology, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 423-430. refs

(Contract NSF ATM-80-20415; NSF ATM-82-09684)

Aircraft charge was measured during penetrations of summer convective clouds in Montana as part of the Desert Research Institute involvement in the Cooperative Convective Precipitation Experiment. An Aerocommander was instrumented to measure electric field, aircraft charge, ice particle type and concentration, precipitation particle charge and the usual meteorological parameters. Preliminary results are presented which point to the importance of ice particles in aircraft charging and are compared with laboratory results at lower impact velocity. Evidence is presented to show that temperature, liquid water content and electric field may affect the sign and magnitude of charging. No evidence was found to link sudden changes in aircraft charge or local electric field to lightning strikes on the aircraft. Author

A86-47334

LIVE TESTS ON STATIC ELECTRICITY IN FUELLING OF AIRCRAFT

H. SCHNEIDER (Luftwaffe, Manching, West Germany) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 451-459. refs

Attention is given to the charge build-up experienced by an aircraft upon fuelling. It is shown how (1) the use of additives can increase the conductivity of distilled fuels, consequently reducing the risk of electrostatic ignition, and how (2) grounding and bonding can prevent the fatal explosions which result from fuel hose coupling/removal. Tests performed on an aircraft fuelled with doped JP-4 and on a helicopter reveal that a resistance of 1 M ohm should suffice for all bonding connections under normal conditions. K.K.

A86-47611

AGEING AIRCRAFT AS SEEN BY AN AUTHORITY

J. W. BRISTOW and B. F. LAVERS (Civil Aviation Authority, London, England) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messgesellschaft mbH, 1985, 13 p. refs

The structural integrity of an aging aircraft is based on three factors: (1) a static strength capability to withstand the load in service, (2) adequate and stable aeroelastic and dynamic characteristics, and (3) tolerance to operational service. The latter aspect is of primary concern for the aging aircraft. The operational effects on the in-service tolerance include structural degradation due to fatigue, material degradation due to environmental effects, and accidental damage occurring during manufacture or maintenance. The evolution of fail-safe aircraft and the procedures followed in a structural integrity audit are described. The considerations of accidental damage relate primarily to such systems as electrical cables, hydraulic pipes, and pneumatic ducts, which are often damaged by being in the way of maintenance work done on other parts. I.S.

A86-47730

THE RISK OF COLLISION IN A TWO SEAT AIRCRAFT EJECTION

J. D. FRITSVOLD and J. E. VETTER (U.S. Navy, Analytical Systems Div., Washington, DC) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 47-54. refs

A86-47731

SCOTT EMERGENCY ESCAPE BREATHING DEVICE - EVALUATION FOR USE IN CANADIAN FORCES AIRCRAFT

N. A. MARTIN (Department of National Defence, Defence and Civil Institute of Environmental Medicine, Downsview, Canada) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 55-58. refs

The Scott Emergency Escape Breathing Device (EEBD) was evaluated for use in Canadian Forces transport or passenger aircraft as a means of providing smoke protection and preventing hypoxia in the event of cabin decompression at high altitude. Testing was carried out in the following four phases: (1) gas production analysis, (2) high temperature operation, (3) in-leakage measurement, and (4) hypoxia protection. The EEBD generated 95-100 percent oxygen for 14.5 to 17.5 min and concentrations inside the hood worn by a human subject rose from 20 percent to 75 percent in about 70 sec, then to near the 100 percent level until the generator failed. It was also found that performance at 80 C was comparable with performance at ambient temperatures and that in-leakage was minimal for subjects with a neck circumference greater than 33 cm. For smaller necks, in-leakage was greater. EEBD was able to prevent hypoxia of crew members for 15 to 17 min following decompression. It is concluded that the device performed well, proving its ability to save lives in the given circumstances. K.K.

A86-47738

HIGH SPEED EJECTION TESTS OF A MODIFIED HYBRID III MANIKIN

G. D. FRISCH, P. E. WHITLEY (U.S. Navy, Naval Air Development Center, Warminster, PA), G. WYDRA, and D. HOLDAWAY (U.S. Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 93-101. refs

Three high air speed (600 KEAS) dynamic ejections, employing a Hybrid III Type manikin and a variety of ejection seats and parachute prototypes, were conducted. These tests showed the manikin to be a viable alternative to presently employed test dummies and a sensitive evaluation tool for assessing restraint efficacy and effects on seat performance with increased human like response on the part of the manikin. Long postulated response mechanisms to dynamic air pressure were demonstrated and possible injury modalities isolated. Author

A86-47744

ADVANCEMENTS IN INERTIA REELS FOR FIXED SEATING AIRCRAFT

R. L. FARRIS and J. M. BYERS (Pacific Scientific Co., Kin-Tech Div., Anaheim, CA) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 137-140.

Recently two new types of Inertia Reels have been developed to react to both strap and vehicle accelerations. Previous to this strap acceleration sensitive inertial locking reels have been predominant. Since the restraint harness straps must accelerate to lock the reel, the seat occupant must move out of the fully back, seated position for locking to occur. This may place him/her in a disadvantageous position for maximum crash protection. With the addition of vehicle acceleration sensitive inertial locking, added protection is supplied as the reel is locked up during the initial crash pulse. Discussed in this paper are crash pulse theory, crash protection concepts, as well as the development and testing of two types of dual mode Inertia Reels. The general aviation 0108 type Reel features automatic lock/automatic unlock control features. The MA-6 military type version has a seat mounted control which must be cycled to manually lock or unlock the reel. Author

A86-47745

EMERGENCY UNDERWATER ESCAPE FROM HELICOPTERS

G. GILLESPIE and W. L. LITTLE (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 152-154.

A86-47756

EVOLUTION OF THE SEAWATER ACTIVATED RELEASE SYSTEM (SEAWARS)

D. W. LONG (U.S. Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 228-232.

The evolution of SEAWARS is traced up to the present ongoing retrofit of Navy ejection-seat-equipped aircraft. SEAWARS consists of two independent self-contained devices that attach to the existing 'Koch' parachute canopy release fittings on the right and left risers. By means of an electronic sensing circuit, SEAWARS senses when it is in seawater and then fires a fresh cartridge which releases the canopy from the aircrew aircrewmember. Qualification for Air Force use, and the unforeseen problems that arose (ie: dimensional incompatibility between SEAWARS and the Koch parachute release fittings, and vulnerability of the electronic equipment) after fleet introduction are also discussed. It is noted that the survival chances of the ejecting aircrewmember have been significantly increased through the use of SEAWARS. K.K.

A86-47759

CONCEPT DEVELOPMENT OF A CANOPY ESCAPE MODULE

J. A. HUBERT (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 250-256. refs

An in-house study is being accomplished to design a lightweight, low-profile escape capsule to meet Air Force requirements for fighter aircraft of the year 2000 and beyond. The goal is to provide: (1) Safe escape within an envelope of 950 KEAS (3060 psfq) from sea level to 42,000 feet and Mach 3.5 from 42,000 feet up to altitudes of at least 100,000 feet, 2) G-protection during aircraft maneuvers, and (3) Ingress and egress in a Nuclear, Biological or Chemical environment. The effort was divided into five concurrent tasks to be completed during FY 1986. The tasks cover the areas of aerodynamics, performance, human factors, crew station design, subsystems integration and graphic analysis. The aerodynamic task includes obtaining low-speed wind tunnel data, computer modeling and use of data from previous capsules. Performance will be established through computer simulation using a modified ejection seat code. The crew station has been designed to provide acceleration protection that may exceed 12 Gs. Seat geometry has been established with instrument and control locations determined. Two possible ingress and egress approaches have been proposed with major capsule subsystems identified. The ability to create animations based on computer generated trajectories has been achieved. The overall design has taken into account emerging technologies such as high speed digital processing, controllable rocket systems, composite materials, millimeter wave radar sensors and advanced flight suits. Author

A86-47760

DEVELOPMENT OF A NEW LIGHTWEIGHT EMERGENCY ESCAPE BREATHING DEVICE

P. PELLOUX-GERVAIS and E. G. WHITE (L'Air Liquide, Sassenage, France) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings . Van Nuys, CA, SAFE Association, 1986, p. 257-260.

The paper reports on the design, development and testing of a new self-contained escape hood designed for use by air crews in emergency situations. The hood can be unpacked and donned in less than 10 seconds and offers 15 minutes protection against noxious smoke and hypoxia. The device is totally self-contained, with both the high pressure pure oxygen supply and carbon dioxide

removal system located inside the hood. The compact, lightweight design results in a hood which allows great freedom of movement together with a wide horizontal and vertical viewing angle. The hood, designed to surpass TSO C99 requirements, is currently undergoing tests with various commercial carriers. Results to date indicate that the hood represents a major step forward in aviation safety.

Author

A86-48669

USE AND MAINTENANCE OF HELICOPTERS ON THE PLATEAU

Q.-C. WEN (Air Force Research Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 4. Alexandria, VA, American Helicopter Society, 1985, 20 p.

Attention is given to the problems typically encountered in helicopter operations in plateau regions, and to the performance and maintenance requirements they generate. An attempt is made to formulate criteria for both the more successful use of current helicopter types and the development of plateau-operation variants of future helicopters. The plateau regions in question are defined as being 3 km above sea level or higher, and are often characterized by windy/sandy conditions, rapidly changing weather, and rough terrain surfaces; useful fuel and payload fractions deteriorate with both increasing altitude and temperature. O.C.

A86-48989#

FIRE SAFETY INVESTIGATIONS FOR MATERIAL SELECTION AND DESIGN OF A CARBON FIBRE REINFORCED FUSELAGE STRUCTURE

E. MIKUS (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 144-148.

A test program for carbon-fiber-reinforced composites is described. Since up to now fuselage structures and skins for large airplanes have always been constructed of aluminum alloys, no certification procedures concerning fire safety of fuselages exist. Therefore a test program has been performed to find criteria for selection of fire-safe materials and constructions for composite civil-aircraft fuselages.

Author

A86-49035#

MANAGING AIRWORTHINESS

P. J. CRAWFORD (British Airways, PLC, London, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 532-535.

Airworthiness is a very broad subject, covering not only the engineering safety of the aircraft, but also its operation, its protection as an asset and the economics of its use. These are all established as a standard during its development by a combination of inputs from the manufacturers, the potential operators and the regulatory authorities. However, what happens when the aircraft has entered service tends to be ignored by the industry as a whole, being left to the individual operator in association with his regulatory authority. This paper attempts to describe how the industry has set about establishing a standard for maintaining the airworthiness of its fleet of aircraft, so that everyone can work to a common approach. This effort will maybe help those operators, particularly the airlines from the emerging countries, to keep abreast of their larger colleagues and competitors.

Author

A86-49036#

CERTIFICATION OF ADVANCED EXPERIMENTAL AIRCRAFT

W. BRADSHAW (British Aerospace, PLC, Military Aircraft Div., Preston, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 536-541. refs

Building upon the core elements of certification - criteria for fitness for flight, the aircraft design, assessment of design against criteria and concurrence that the design meets the criteria - the general principles of the certification process are developed. Factors influencing certification are explored. The certification procedure for the British Aerospace Experimental Aircraft Programme is briefly discussed outlining some of the documentation developed. Finally, it is concluded that when certifying advanced experimental aircraft the significant factor is the choice of and extent of application of codes of design and airworthiness requirements.

Author

A86-49053*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

STRUCTURAL DYNAMICS RESEARCH IN A FULL-SCALE TRANSPORT AIRCRAFT CRASH TEST

H. G. MCCOMB, JR., R. J. HAYDUK (NASA, Langley Research Center, Hampton, VA), and R. G. THOMSON IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 703-713. refs

A remotely piloted air-to-ground crash test of a full-scale transport aircraft was conducted for the first time for two purposes: (1) to demonstrate performance of an antimisting fuel additive in suppressing fire in a crash environment, and (2) to obtain structural dynamics data under crash conditions for comparison with analytical predictions. The test, called the Controlled Impact Demonstration (CID), was sponsored by FAA and NASA with cooperation of industry, the Department of Defense, and the British and French governments. The test aircraft was a Boeing 720 jet transport. The aircraft impacted a dry lakebed at Edwards Air Force Base, CA. The purpose of this paper is to discuss the structural aspects of the CID. The fuselage section tests and the CID itself are described. Structural response data from these tests are presented and discussed. Nonlinear analytical modeling efforts are described, and comparisons between analytical results and experimental results are presented.

Author

A86-49054#

A STUDY OF THE STRUCTURAL INTEGRITY OF THE CANADAI R CHALLENGER AT DITCHING

P. T. TO (Canadair, Ltd., Montreal, Canada) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 714-723. refs

The ditching characteristics and the structural response of the Canadair CL-600 Challenger was studied with a 1/10 scale instrumented dynamic model. The peak structural loading occurs when the attitude of the aircraft reduces abruptly after attaining a high pitch up angle which has been gradually building up from the initial impact. To optimize the acceleration and impact pressure emergency landing on water should be carried out at speed slightly higher than the stall speed with flaps extended and landing gears retracted. In high sea states, a parallel landing on the crest of the waves will improve the chance of successful ditching though the impact pressure is compromised. The relatively mild and brief acceleration and favorable post ditching flotation will provide satisfactory occupant survivability.

Author

A86-49069#

TAKE-OFF AND LANDING IN A DOWNBURST

K.-U. HAHN (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 860-869. DFG-supported research. refs

The main parameters of influence on an aircraft flying through a downburst are discussed. A simple method is used to calculate the energy height error along a constant flight path, and flight path patterns computed by aircraft simulations using nonlinear differential equations of motion are compared with accident flight paths. It is concluded that the reasons for approach accidents cannot be found exclusively in the wind situation in the core of a downburst. The critical situation results from the fact that the aircraft's thrust setting for the approach is performed before it reaches the downburst. Pilots thus need better information before encountering the downburst. Wind conditions in a given downburst are more dangerous during takeoff than during landing. In moderate downbursts, a practical escape maneuver is level flight at low height to pass the core of the downburst before starting to climb.

C.D.

A86-49083#

EXPERIMENTAL INVESTIGATION OF ELECTROSTATIC FIRE AND EXPLOSION ACCIDENTS AFTER AIRCRAFT LANDING AND PREVENTIVE DESIGN

L. HAN-SENG (Chinese Air Force, Scientific Research Institute, Beijing, People's Republic of China) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 998-1009.

Research on several electrostatic fire and explosion accidents involving fuel tanks that occurred after aircraft landings is summarized. The significance for starting fires of the charging state in the fuel tank, electrostatic leakage in the tank, the effect of environment on the charging in the tank, the formation of flammable vapor inside the tanks, and sources of dangerous electrostatic ignition are discussed. Preventive measures are considered, including the prevention of the formation of a flammable fuel/air mixture, of the generation of static electricity by the fuel, and of the charging of fuel, and dissipating dangerous electric charges, are addressed.

C.D.

A86-49107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA'S AIRCRAFT ICING ANALYSIS PROGRAM

R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1254-1269. refs

An overview of the NASA ongoing efforts to develop an aircraft icing analysis capability is presented. Discussions are included of the overall and long term objectives of the program as well as current capabilities and limitations of the various computer codes being developed. Descriptions are given of codes being developed to analyze two- and three-dimensional trajectories of water droplets, airfoil ice accretion, aerodynamic performance degradation of components and complete aircraft configurations, electrothermal deicer, fluid freezing point depressant antideicer and electro-impulse deicer. The need for bench mark and verification data to support the code development is also discussed, and selected results of experimental programs are presented. Author

A86-50259*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

F-106 DATA SUMMARY AND MODEL RESULTS RELATIVE TO THREAT CRITERIA AND PROTECTION DESIGN ANALYSIS

F. L. PITTS, G. B. FINELLI (NASA, Langley Research Center, Hampton, VA), R. A. PERALA, and T. H. RUDOLPH (Electro Magnetic Applications, Inc., Lakewood, CO) 1986 Conference on Lightning and Static Electricity, Dayton, OH, June 24-26, 1986, Paper. 27 p. refs

The NASA F-106 has acquired considerable data on the rates-of-change of electromagnetic parameters on the aircraft surface during 690 direct lightning strikes while penetrating thunderstorms at altitudes ranging from 15,000 to 40,000 feet. These in-situ measurements have provided the basis for the first statistical quantification of the lightning electromagnetic threat to aircraft appropriate for determining lightning indirect effects on aircraft. The data are presently being used in updating previous lightning criteria and standards developed over the years from ground-based measurements. The new lightning standards will, therefore, be the first which reflect actual aircraft responses measured at flight altitudes. The modeling technique developed to interpret and understand the direct strike electromagnetic data acquired on the F-106 provides a means to model the interaction of the lightning channel with the F-106. The reasonable results obtained with the model, compared to measured responses, yield confidence that the model may be credibly applied to other aircraft types and uses in the prediction of internal coupling effects in the design of lightning protection for new aircraft.

Author

N86-31548*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA'S AIRCRAFT ICING ANALYSIS PROGRAM

R. J. SHAW 1986 26 p Presented at the International Conference of the Aeronautical Sciences (ICAS), London, England, 7-12 Sept. 1986

(NASA-TM-88791; E-3121; NAS 1.15:88791) Avail: NTIS HC A03/MF A01 CSDL 01C

An overview of the NASA ongoing efforts to develop an aircraft icing analysis capability is presented. Discussions are included of the overall and long term objectives of the program as well as current capabilities and limitations of the various computer codes being developed. Descriptions are given of codes being developed to analyze two and three dimensional trajectories of water droplets, airfoil ice accretion, aerodynamic performance degradation of components and complete aircraft configurations, electrothermal deicer, fluid freezing point depressant antideicer and electro-impulse deicer. The need for bench mark and verification data to support the code development is also discussed, and selected results of experimental programs are presented. Author

N86-31549# Test Wing (4950th), Wright-Patterson AFB, Ohio. FIREPROOF HYDRAULIC BRAKE SYSTEM Final Report, May - Nov. 1985

M. W. DILLARD Apr. 1986 66 p (AD-A167774; REPT-4950/FTR-86-1) Avail: NTIS HC A04/MF A01 CSDL 13G

The Fireproof Hydraulic Brake System (FHBS) flight test program verified that the FHBS is a feasible method of eliminating aircraft hydraulic fluid fires ignited by hot brakes. The FHBS uses a new nonflammable hydraulic fluid, chlorotrifluoroethylene (CTFE), in the wheel well and landing gear area while retaining standard hydraulic fluid (MIL-H-5606) in the rest of the aircraft hydraulic system. The two fluids were separated downstream of the antiskid valve by a reservoir/separator unit. A C-135E was used as the test aircraft. The modification consisted of instrumentation to monitor brake system parameters and the FHBS installation for the left outboard wheel pair. The testing consisted of maximum effort braking runs at light aircraft gross weights to induce antiskid cycling. The FHBS was evaluated subjectively by the test pilot and objectively by comparing its performance with that of the standard C-135 brake system established by baseline testing.

GRA

N86-32416# Lockheed-California Co., Burbank.
KRASH 85 USER'S GUIDE: INPUT/OUTPUT FORMAT, REVISION
Final Report, Jan. - Sep. 1984
 M. A. GAMON, G. WITTLIN, and B. L. LABARGE Mar. 1986
 237 p
 (Contract DTFA03-84-C-0004)
 (AD-A168846; LR-30777-REV; DOT/FAA/CT-85/10-REV) Avail:
 NTIS HC A11/MF A01 CSCL 09B

Program KRASH, originally developed under Federal Aviation Administration sponsorship for predicting the response of general aviation airplanes to an impact environment, has been enhanced to include features that would facilitate the modeling of transport category airplanes. This document is the User's Guide which defines the input and output formats appropriate for this new version of Program KRASH known as KRASH 85. GRA

N86-32418# General Accounting Office, Washington, D. C.
 Resources Community and Economic Development Div.
AIR SAFETY: FEDERAL AVIATION ADMINISTRATION'S ROLE
IN DEVELOPING MID-AIR COLLISION AVOIDANCE BACK-UP
SYSTEMS
 Apr. 1986 19 p
 (PB86-197506; GAO/RCED-86-105FS; B-222851) Avail: NTIS
 HC A02/MF A01 CSCL 01B

This FAA report on the development of mid-air collision avoidance back-up systems contains the following: Airborne collision avoidance system availability; Difference between the traffic alert and collision avoidance system and the beacon collision avoidance system; Traffic alert and collision avoidance system projected commercial availability date; Airborne collision avoidance system and threat alert and collision avoidance system cost and effectiveness. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A86-47517#
AN ALL-WEATHER MULTIMODE LANDING SYSTEM FOR
TACTICAL FIGHTER AIRCRAFT
 G. A. WEICHEL, J. M. URNES (McDonnell Aircraft Co., St. Louis, MO), and J. S. JARRETT (U.S. Navy, Naval Air Systems Command, Washington, DC) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 8 p.
 (Contract N00019-83-G-0412)
 (AIAA PAPER 86-2146)

Multimode Landing System (MLS) components are described which are designed to fit in the same space as the Instrument Landing System (ILS) components presently installed on Navy and Marine tactical aircraft, and the system will receive and process signals from Navy and Marine ILS systems, conventional Military/Civil ILS systems, and the Microwave Landing System. The interface control law design to link the Multimode receiver-processor units with the aircraft flight computer and cockpit displays is described, and the control configuration will also integrate INS, air data, and throttle control systems, reducing software size and cost. The capability of automatic flight couple control for segmented flight path profiles from extended ranges to the runway will reduce time and fuel in Tactical aircraft recovery simulated flight path control response is given for an F/A-18 configuration, including aircraft response during approach and in turbulence. R.R.

A86-47519#
HELICOPTER IFR DIRECTOR ALGORITHM DEVELOPMENT
AND FLIGHT EVALUATION ON THE NAE AIRBORNE
SIMULATOR
 D. E. SATTLE (National Research Council of Canada, Flight Research Laboratory, Ottawa) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 28 p.
 FAA-supported research. refs
 (AIAA PAPER 86-2205)

Attention is given to the development and evaluation of a three cue (i.e., roll, pitch and collective) flight director system, which in combination with a relatively austere stability and control augmentation can provide the small-to-medium sized helicopter with a greatly enhanced IFR capability. The flight director algorithms were designed from first principles and analyzed with root-locus and time-response methods. The analysis provided an indepth understanding of performance issues and in effect made flight evaluation on the National Aeronautical Establishment Airborne simulator a possibility. Consideration is given to the use of feedback washout versus forward integration, suitable sources for system damping, the equivalence of pilot lead and derivative feedback, the placement and extent of limiting functions, and the general interaction between the flight director system and the flight control system. K.K.

A86-47703#
CONCEPT OF AUTOMATED AIRCRAFT GUIDANCE SYSTEM
FOR AIR-TO-AIR MISSIONS
 J. SHINAR (Technion - Israel Institute of Technology, Haifa) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 510-517. refs
 (AIAA PAPER 86-2285)

There is a clear requirement for automated guidance modes in the air-to-air tasks of an advanced fighter. Technologically the idea seems to be feasible. The paper outlines a conceptual architecture design which integrates a family of feed-back algorithms, approximating the optimal control strategies in different air-to-air scenarios, into an operationally useful subsystem, an inherent component of the aircraft fire and flight control system. The automated guidance algorithms have a great potential usefulness in a future 'pilot's associate' scheme. Author

A86-47769#
OBSTACLE WARNING RADAR FOR HELICOPTERS - AN
ANTHROPOTECHNICAL PROBLEM [DAS
HINDERNISWARNRADAR FUER HUBSCHRAUBER - EINE
ANTHROPOTECHNISCHE PROBLEMSTELLUNG]
 G. M. OCH (Telefunken AG, Ulm, West Germany) IN: Evaluation of man-machine systems: Methods and problems; Symposium, November 14, 15, 1985, Cologne, West Germany, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 25-33. In German.

An obstacle warning radar concept for helicopters is described in both the test and operational phases. A radar sonde is mounted on the front of the helicopter under a radome and senses the atmosphere forward over a range of 180 deg azimuth and 32 deg elevation. The ray is directed by a fast-rotating mirror, resulting in an image-renewal rate of two per second. Obstacles can be detected to a distance of 800 m, depending on atmospheric conditions and obstacle size. C.D.

A86-48372
SECONDARY RADAR LEADS - MONOPULSE POINTS THE
WAY

D. BOYLE Interavia (ISSN 0020-5168), July 1986, p. 773, 774.
 Secondary surveillance radar (SSR) is now an integral and important part of automated ATC systems, since it is the only form of simple data link furnishing identity and altitude data for each radar plot; this allows automated radar data processing systems to provide controllers with a labelled display indicating the position and identity of all aircraft. Attention is presently given to recent improvements in SSR sensor technology, which

encompass monopulse technology capable of measuring angles-of-arrival, and large vertical aperture antennae, which furnish better control over the shape of the beam of the interrogator-transmitted signal in the vertical plane. The Mode S SSR currently under development in the U.S. is also monopulse, but provides selective address and collision-avoidance warning.

O.C.

A86-48564

ANALYSIS AND SIMULATION OF THE MLS LANDING SIGNAL - ECHO SEPARATION [ANALYSE ET MODELISATION DU SIGNAL D'ATTERRISSAGE MLS SEPARATION D'ECHOS]

J.-M. BOIS Toulouse, Institut National Polytechnique, Docteur-Ingenieur Thesis, 1985, 195 p. In French. refs

Numerical signal-processing techniques are applied to the signal of the time-reference-scanning-beam MLS being implemented under ICAO guidelines. The scanning signal is simulated by modeling an electronic-scanning antenna; the noise and echos responsible for the secondary lobes in the characteristic signal are analyzed by means of spectra, autocorrelations, and a model based on an adaptive predictor filter; a number of echo-detection and echo-separation methods (including cepstral analysis) are compared; and a novel method combining the energy cepstrum, identification by a nonrecursive filter, and deconvolution by a recursive lobe model is developed and demonstrated. T.K

A86-48581

LASER COMMUNICATION THROUGH LOW-VISIBILITY ATMOSPHERE FOR AIRCRAFT APPLICATION

A. K. MAJUMDAR (Lockheed-California Kelly Johnson Research and Development Center, Burbank) Lockheed Horizons (ISSN 0459-6773), April 1986, p. 50-57.

Recent experiments at Lockheed's Kelly Johnson Research and Development Center are being performed on a laboratory scale to determine the possibility of improved atmospheric optical communication through low visibility weather by exploitation of scattered light. The experiments have application to providing communications from satellite to aircraft, satellite to submarine, aircraft to aircraft, and aircraft to submarine. Semiconductor diode lasers are used, which can be modulated at rates above 6 GHz by direct current injection. It has been possible to replicate a cloudy atmosphere a few kilometers thick in the laboratory, using a 12.7-cm-long scattering cell. A background light simulator (simulating a background sun behind a signal source) directs the beam from a quartz-halogen lamp toward a collimating lens system transmitting through a beam splitter. The problem of maximizing the data rate and minimizing the bit error rate through the use of pulse position modulation is treated. An ultrashort pulsed diode laser experiment is described - a study that is considered useful in designing adaptive filters for improving all-weather optical communications performance. Field experiments between two buildings about a kilometer apart are under way. D.H.

A86-49016#

LOW COST INERTIAL REFERENCE SYSTEM BASED ON FIBER GYROS WITH GPS-AIDING

D. RAHLFS (Standard Elektrik Lorenz AG, Stuttgart, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 370-375. BMFT-supported research.

Inertial reference systems play an important role within modern flight control and navigation systems. This is especially true for strapdown system mechanizations, which deliver complete multilevel informations - acceleration, rate, velocity, position and attitude - for any needed coordinate system. Due to the latest progress in the field of development of fiber optic gyros and low cost satellite navigation (GPS) receivers, it is now possible to design an all solid-state low cost solution for a flight control and navigation reference system. The present system consists of an 'integrated fiber optic gyro strapdown/magnetic sensor/GPS system'. A functional description and the system mechanization are presented together with the first results of system simulations.

The ground and inflight alignment methods are discussed.

Author

A86-49017#

TEST AND FLIGHT EVALUATION OF PRECISION DISTANCE MEASURING EQUIPMENT

K. BECKER, A. MUELLER (Standard Elektrik Lorenz AG, Stuttgart, West Germany), and K. H. HURRASS (DFVLR, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 376-383.

The International Civil Aviation Organization has described a new type of precision distance measuring equipment (DME/P), that will be an integral part of the coming microwave landing system. It is based on two modes for the initial approach and final approach phases. Compared to the conventional Distance Measuring Equipment, accuracy is increased by almost an order of magnitude, while the immunity against multipath reception is significantly improved. New developed ground and airborne DME/P equipment is introduced, and laboratory results on the instrumentation accuracy and the measured multipath immunity are discussed. For flight testing of the DME/P, a novel avionics flight evaluation system was employed providing high precision reference positions of the test aircraft. Some typical flight test results are presented and commented on. Author

A86-49018*#

National Aeronautics and Space Administration.

FLIGHT MANAGEMENT CONCEPTS COMPATIBLE WITH AIR TRAFFIC CONTROL

S. A. MORELLO (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 384-391. refs

With the advent of airline deregulation and increased competition, the need for cost efficient airline operations is critical. This paper summarizes past research efforts and planned research thrusts toward the development of compatible flight management and air traffic control systems that promise increased operational effectiveness and efficiency. Potential capacity improvements resulting from a time-based ATC simulation (fast-time) are presented. Advanced display concepts with time guidance and velocity vector information to allow the flight crew to play an important role in the future ATC environment are discussed. Results of parametric sensitivity analyses are also presented that quantify the fuel/cost penalties for idle-thrust mismodeling and wind-modeling errors. Author

A86-49034#

A SIMULATION FACILITY FOR ASSESSING THE NEXT GENERATION OF 4-D AIR TRAFFIC CONTROL PROCEDURES

A. BENOIT and S. SWIERSTRA (EUROCONTROL, Brussels, Belgium) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 531a-531h.

A method whereby the characteristics of any airline or air traffic control procedure may be analyzed in terms of trajectories, control load, fuel consumption, and flight cost is described. The program developed provides a high degree of realism in the performance of air traffic control simulations as required for systems such as the Zone of Convergence concept. Author

A86-49637*#

National Aeronautics and Space Administration.

ADVANCED ATC - AN AIRCRAFT PERSPECTIVE

L. CREDEUR, D. H. WILLIAMS, W. E. HOWELL, and C. R. SPITZER (NASA, Langley Research Center, Hampton, VA) NATO, AGARD, Symposium on Efficient Conduct of Individual Flights and Air Traffic, Brussels, Belgium, June 10-13, 1986, Paper. 15 p. refs

The principal operational improvements desired by commercial aircraft operators in the United States are efficient aircraft operations and delay reductions at the major terminals. This paper describes efforts underway within the Advanced Transport

Operating Systems Program at the Langley Research Center to provide a technology basis for reducing delay while improving aircraft efficiency. The principal thrust is the development of time-based traffic control concepts which could be used within the framework of the upgraded National Airspace System and which would allow conventionally equipped aircraft to operate in a manner compatible with advanced aircraft. Author

N86-31551*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SIMULATION EVALUATION OF DISPLAY/FLIR CONCEPTS FOR LOW-ALTITUDE, TERRAIN-FOLLOWING HELICOPTER OPERATIONS

H. N. SWENSON, C. H. PAULK, JR., R. L. KILMER (IBM Federal Systems Div., Owego, N. Y.), and F. G. KILMER Dec. 1985 13 p

(NASA-TM-86779; REPT-85349; NAS 1.15:86779) Avail: NTIS HC A02/MF A01 CSCL 17G

A piloted simulation of three head-down display (HDD) concepts with flight-director guidance superimposed on forward-looking infrared (FLIR) imagery was performed to evaluate the task of low-level, terrain-following (TF), manual helicopter flight. The three display concepts were examined for the purpose of finding ways by which aircraft flight-attitude and command symbols and FLIR imagery could be integrated onto one instrument. In all cases, the FLIR imagery was centered on the flight-path vector of the aircraft. The three displays were then characterized by having: (1) pitch attitude conformal to the FLIR imagery; (2) pitch attitude conformal to the FLIR imagery, but with an increase in the scaling; and (3) pitch attitude nonconformal to the FLIR imagery with the same pitch scaling as in (2). The simulation was conducted on the Vertical Motion Simulator (VMS) at Ames Research Center, using NASA and Air Force test pilots. The pilots indicated that the nonconformal pitch attitude and FLIR display was the preferred way to display information because of the absence of pitch-attitude information on displays (1) and (2) during some portions of the operational flight envelope. Author

N86-31552# Department of the Air Force, Washington, D.C.

PORTABLE GLIDE SLOPE INDICATOR Patent Application

H. L. TASK, inventor (to Air Force) 26 Jan. 1986 15 p (AD-D012240; US-PATENT-APPL-SN-823872) Avail: NTIS HC A02/MF A01 CSCL 17G

An improved glide slope indicator system for facilitating aircraft landings under adverse lighting conditions on remote or austere landing sites is provided which comprises a pair of indicators deployable near ground level on each side of a runway, each indicator including a housing having an optical window and a pair of light sources mounted in predetermined spaced relationship to each other and to the optical window and connected to a power source and related circuitry to project a well defined first blinking and second steady light beam of predetermined angular divergence and overlap, one indicator disposed to project beams with an overlap elevated at a first angle relative to horizontal and the other indicator disposed to project beams with an overlap elevated at a second angle relative to horizontal different from the first, with a preselected glide path lying between the two overlaps. An infrared filter may be included in each indicator to project beams observable only with infrared sensitive viewing aids. The system may be battery powered for portability. GRA

N86-31554# Arinc Research Corp., Annapolis, Md. **EVALUATION OF ALTERNATIVES FOR AN ARMY PRECISION LANDING SYSTEM Final Report**

R. LANCASTER, R. LEWSEN, and B. MITCHELL Sep. 1985 130 p

(Contract DAEA18-84-C-0127)

(AD-A167780; REPT-2959-01-1-3759) Avail: NTIS HC A07/MF A01 CSCL 17G

This study was conducted to determine the need for Army Precision Landing System requirements for aviation deployment in the combat zone. The study identifies the need and best approaches for satisfying Army requirements within air traffic

management functions, applying current tactical doctrine. Existing landing systems are compared with alternate systems not presently developed or fielded from a technical and operational viewpoint. Availability, operational concepts, and cost data are analyzed for each proposed system. The study also developed strengths and weaknesses of the existing, as well as proposed precision landing systems for ATC. Final results and recommendations to support air traffic control requirements on the battlefield beyond the year 2000 are depicted. GRA

N86-31555# Federal Aviation Administration, Atlantic City, N.J.

LORAN C 1984 SPRING-SUMMER STABILITY

F. LORGE Mar. 1986 81 p (AD-A167867; DOT/FAA/CT-TN86/10) Avail: NTIS HC A05/MF A01 CSCL 17G

The report describes a flight test designed to examine Loran C seasonal stability. Flights were conducted in the spring and summer of 1984. Plot data are presented which show seasonal shifts in signal-to-noise ratio, envelope-to-cycle discrepancy, and time differences across the continental United States. A later report will compare these data to new data collected in the winter season. GRA

N86-31556# Aeronautical Research Labs., Melbourne (Australia).

ANALYSIS OF A MIRROR DECK LANDING AID

A. ROSS Feb. 1986 64 p (AD-A167988; ARL/SYS-TM-86) Avail: NTIS HC A04/MF A01 CSCL 01D

This report provides details of the MDLA system, installation details and calculations concerning performance, coverage, calibration and accuracy requirements. A graphical method of presenting operational settings for height and elevation is described, as also is a simplified technique for calibration. GRA

N86-31558# European Space Agency, Paris (France).

A FEASIBILITY STUDY FOR THE USE OF ELECTRONIC FLIGHT STRIPS IN AIR TRAFFIC CONTROL (ATC) CONTROLLER WORKSTATIONS

J. GRIGAT and J. THOMAS Oct. 1985 89 p Original language document was announced as N85-31039 (ESA-TT-928; DFVLR-FB-85-08; ETN-86-97572) Avail: NTIS HC A05/MR A01; original German version available from DFVLR, Cologne, West Germany DM 47

Flight progress strip importance in air traffic control was studied and a concept for flight strip representation on electronic displays supported by an automatic data exchange between adjacent control stations and adapted to the ATMOS (Air Traffic Management and Operations Simulator) air traffic control simulator was developed. Data important for executive controllers and for schedule controllers per sector and per flight are displayed on two different screens. The concept allows a rapid exact data exchange to all workstations and a reduction in the controllers data acquisition so that they can dedicate their attention to approach monitoring. Pilot communications are also reduced. The feasibility of the concept is demonstrated in a case study. ESA

N86-32419 National Aerospace Lab., Amsterdam (Netherlands). Afdeling Vliegtuigen.

PRELIMINARY DESIGN OF AN AUTOMATED AIR TRAFFIC CONTROL (ATC) RADAR EVALUATION SYSTEM [VOORONTWERP VOOR EEN GEAUTOMATISEERD ATC-RADAR EVALUATIE SYSTEEM]

J. VANKASTEEL 27 Apr. 1984 21 p In DUTCH (Contract RB-RD-1984-3.1)

(NPL-VG-84-009-L; ETN-86-97779) Avail: Issuing Activity

An automated system to support regular evaluations of radar systems of the government aviation service is presented. The system provides the quality parameters for the combination of sensor and extractor and for the tracker. It determines these parameters from plot and track information and from external reference information if necessary. Simulated plot information can also be used for tracker evaluation. The system consists of

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

subsystems for radar data recording and selection, path reconstruction, sensor/extractor evaluation, and tracker evaluation. The definitions of the quality parameters to be calculated are given. ESA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A86-47295

ELECTROMAGNETIC INTERACTION OF EXTERNAL IMPULSE FIELDS WITH AIRCRAFT

H. D. BRUENS and H. SINGER (Hamburg, Hochschule der Bundeswehr, West Germany) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 13-20. refs

The paper deals with the coupling of lightning and nuclear EMP (LEMP and NEMP) fields into aircraft. The theory is based on the method of moments, with a special technique for the treatment of wire junctions. The aircraft is simulated by a stick model or a wire junction model. The calculations are performed in the frequency domain with spectra of 6-60,000 kHz and 100-100,000 kHz, respectively, using a Fourier transformation for the transition to the time domain. By means of these calculations resonance frequencies along the structure and the time-dependent behavior of the currents are determined, comparing the results for LEMP and NEMP type fields. The way in which the results are changed by using composite materials (CFRP) instead of metals for the aircraft is also studied. Author

A86-47297

INDUCED CURRENT SURFACE DENSITY AFTER A DIRECT LIGHTNING STRIKE ON AN AIRCRAFT

Y. BENIGUEL (Laboratoire Central des Telecommunications, Velizy-Villacoublay, France) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 25-28.

A method for calculating the current following a direct lightning strike on an aircraft is described. A time domain algorithm which computes the current surface density on a structure of arbitrary shape is developed. In order to represent the direct lightning strike, it is hypothesized that the source current is impinging on the aircraft at one point and leaving the aircraft at another point. The computer simulations carried out with the proposed code show that the current density at any point on the aircraft has the same time dependence as the source current and that the value obtained at a particular point depends on the location of this point on the aircraft. K.K.

A86-47305

IMPLEMENTATION OF A CROWBAR SWITCH IN A MARX GENERATOR/PEAKING CAPACITOR LIGHTNING SIMULATOR SYSTEM

R. A. PERALA, P. M. MCKENNA, T. H. RUDOLPH (Electro Magnetic Applications, Inc., Denver, CO), and J. D. ROBB (Lightning and Transients Research Institute, St. Paul, MN) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 121-125. refs

An account is given of the problems which arise when a high voltage Marx generator is used for lightning simulation and it is shown how the implementation of a 'crowbar' switch can provide

a long late time damped exponential current. The crowbar switch approach is first applied to a uniform cylindrical test object and then to a three-dimensional model of an F-16 aircraft. Analysis shows that the crowbar switch can be used to accomplish the desired objectives. However, since this test approach does introduce spurious resonances from the test fixture/aircraft interaction, a method is needed for terminating the aircraft such that these resonances are minimized. The method introduced in the present study works well for a uniform cylinder but not for a real aircraft geometry. K.K.

A86-47306

THE OBSERVATION OF HIGH FREQUENCY B(DOT) AND D(DOT) TRANSIENTS EXCITED ON A FUSELAGE BY AN IMPULSE GENERATOR

C. J. HARDWICK and V. P. DUNKLEY (U.K. Atomic Energy Authority, Culham Laboratory, Abingdon, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 127-135. Research supported by the Ministry of Defence (Procurement Executive). refs

High-frequency transients in the MHz range of both B(dot) and D(dot) (the rates of change of B and D) on a Hawker Hunter fuselage subjected to a simulated lightning strike have been observed. The magnitude and frequency content of the waveforms and their variation with position on the fuselage have been measured, and a comparison is made with various models of the fuselage-lightning simulator system. Both distributed and lumped models of the transmission line formed by the fuselage and the conductors connecting it to the lightning generator give a reasonable description of the transients. The D(dot) transients are quite large and can induce large voltages on exposed high-impedance circuits. Author

A86-47307

LIGHTNING SIMULATION TESTS ON FAA CV-580 LIGHTNING RESEARCH AIRCRAFT

L. C. WALKO and J. L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 137-147. refs

Lightning simulation tests were performed by the United States Air Force Wright Aeronautical Laboratories Atmospheric Electricity Hazards Group on a specially instrumented Federal Aviation Administration Convair CV-580 aircraft. The mission of this aircraft is to obtain information on the characteristics of airborne lightning attachment to the aircraft. In June 1984, the aircraft was subjected to high current pulses such as would be encountered from lightning return strokes during lightning attachment. During these tests current pulses of up to 115 kA were applied to the aircraft. In October 1984, after the summer CV-580 in-flight program, additional simulation tests were performed. A fast risetime lightning generator was used to apply current pulses of up to 46 kA, with risetimes of under 200 nanoseconds. This paper describes the tests performed, the test setups and a comparison of the results from each of the tests. Author

A86-47308

MULTIPATH LIGHTNING PROTECTION FOR COMPOSITE STRUCTURE INTEGRAL FUEL TANK DESIGN

R. O. BRICK (Boeing Commercial Airplane Co., Seattle, WA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 149-155. refs

Attention is given to a design development program which eliminates potential lightning induced ignition sources for a graphite composite integral fuel tank skin-spar joint. This program involves the combination of two or more lightning protection techniques so as to offer a greater range and flexibility of designs. In effect it

provides safe, reliable, cost effective lightning protection for a transport aircraft composite structure. It is noted that the proposed lightning protection techniques are capable of withstanding the severe direct lightning attachment to a skin-spar fastener. The advantages and disadvantages of the multipath lightning protection concept are presented for a graphite-epoxy skin-spar joint in a lightning Zone 2 swept stroke area. K.K.

A86-47309

OPTICAL DETECTION METHODS FOR TESTING OF FUEL TANK LIGHTNING IGNITION HAZARDS

F. J. ANDERSON, J. D. ROBB (Lightning and Transients Research Institute, St. Paul, MN), G. D. FREIER, and T. S. LEE (Minnesota, University, Minneapolis) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 157-165. USAF-Navy-supported research. refs

A theoretical and experimental investigation was carried out to evaluate current optical methods for detecting sparking and hot spots in fuel tanks. Consideration was given to the following methods: (1) photography, (2) photomultipliers (with optical cable and spherical mirrors) (3) image intensifiers, (4) infrared photo detectors, and (5) heat sensitive paints. The detection methods are presented in terms of the margins between the light emission of a spark having a 10 nanosecond time duration and the sensitivity of the detection methods being used. It is concluded that photographic detection of incendiary sparks can be used out to distances of 9 feet with 35 mm cameras and that electronic detection systems such as photomultipliers can be used in larger fuel tanks with mirrors and possibly optic cable out to distances of 24 feet or greater. Polaroid cameras can be used out to distances of three feet with lenses faster than F 4.7 and/or films faster than ASA 3000. K.K.

A86-47317

AIRCRAFT LIGHTNING ATTACHMENT AT LOW ALTITUDES

P. L. RUSTAN, JR. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and J. P. MOREAU (ONERA, Chatillon-sous-Bagneux, France) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 259-265. refs

The evolution of the EM field during lightning attachment to aircraft at low altitudes is discussed, summarizing the results of measurements obtained at 2000-18,000 ft on WC-130, CV-580, and C-160 aircraft during the period 1981-1984. Typical data are presented graphically and characterized. A typical discharge is found to comprise a 1-2-ms leader process, a fast pulse similar to a ground return stroke, a very active 20-60-ms phase with pulse repetition rate 1 kHz, and a final phase with isolated pulses. The need for both continuous wideband analog recording and high-frequency-resolution analysis of individual pulses on ns time scales is stressed. T.K.

A86-47318* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RESEARCH IN LIGHTNING SWEEP-STROKE ATTACHMENT PATTERNS AND FLIGHT CONDITIONS WITH THE NASA F-106B AIRPLANE

B. D. FISHER, P. W. BROWN (NASA, Langley Research Center, Hampton, VA), and J. A. PLUMER (Lightning Technologies, Inc., Pittsfield, MA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 267-280. refs

Data on 637 direct lightning strikes and 117 close flashes observed by the NASA instrumented F-106B aircraft as part of the Storm Hazards Program at NASA Langley during 1980-1984 are compiled and analyzed, updating the report of Fisher and Plumer (1983). The airborne and ground-based measurement and

recording apparatus and the flight and data-reduction procedures are described, and the results are discussed in terms of lightning-strike-conductive flight conditions and lightning attachment patterns. A peak strike rate of 2.1/min is found at altitude 38,000-40,000 ft and temperature below -40 C, with very few strikes below 20,000 ft. Four categories of swept-flash attachment pattern are identified, but it is pointed out that all exterior surfaces of the F-106B are potential attachment sites. T.K.

A86-47326

SPECIAL PROTECTION CIRCUITS AGAINST TRANSIENT CURRENTS FOR AIRCRAFT SYSTEMS

J. L. TER HASEBORG and H. TRINKS (Hamburg, Technische Universitaet, West Germany) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 363-366.

The early and late time responses of two different protection circuits, similar to those employed in aircraft systems against transient currents, were measured using a specially designed facility. Each protection circuit consisted of a gas arrester, for coarse protection, and a suppressor diode, for fine protection. The results have shown that the electrical dimensions, shieldings, and, mainly, the arrangement of the components may influence the output voltage considerably, particularly in the case of the early time response. This presents a problem for designing protection circuits with small dimension, as required for electronic aircraft systems. For protection circuits of low frequency systems or transmission lines, which are not capable of transmitting the oscillations and pulses of the early time response, only the late time response has to be considered. A protection circuit has been designed, with an arrangement of the circuit components that yielded an improved performance. The circuit diagrams and response results are included. I.S.

A86-47327

LIGHTNING-INDUCED TRANSIENT TEST ON A TRANSPORT AIRCRAFT

C. KING (Boeing Commercial Airplane Co., Seattle, WA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 367-370.

The lightning protection design of a modern jetliner is discussed together with details of an aircraft ground test used for design validation. Measured engine control wiring voltage and current responses are compared with values obtained by means of an analytical/empirical computer model. For the aircraft under consideration, the test current waveforms were chosen to be consistent with the 1978 SAE AE4L report for oscillatory waveforms G1 and G2. The former simulates the lower frequencies of lightning while the latter simulates the higher frequencies. The high-current lightning test setup simulates the worst-case current path through the aircraft with respect to induced transients on the wiring of the stuck engine. For the present design, the analytical model updated by swept CW measurements indicates a maximum lightning-induced transient of 220 V open circuit. Linear extrapolation of the pulse test measurements results in an open-circuit voltage of 78 V on a typical engine wire and it is shown that the transient voltages of both methods are well below the 600-V equipment qualification requirement. K.K.

A86-47331

LIGHTNING STROKE TESTS AT THE CFRP HORIZONTAL STABILIZER OF ALPHA JET

TH. THIELE (Dornier GmbH, Friedrichshafen, West Germany) and G. BOES (Hannover, Universitaet, Hanover, West Germany) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 395-401.

Attention is given to tests performed on the lightning protection system of the Alpha Jet CFRP horizontal stabilizer. This protection system provides: (1) surface protection for the leading edge section and the spar box, and (2) frame protection for the spar box, the leading edge and trailing edge sections. The compliance test used was the lightning stroke I/1. Results of the lightning tests and of subsequent nondestructive tests demonstrated that the lightning protection system selected for the CFRP horizontal stabilizer fulfills its task; none of the lightning strokes applied to the component caused substantial damage. K.K.

A86-47333

CORONA THRESHOLD DETERMINATION BY THREE-STAGE PHYSICAL MODELLING OF AIRCRAFT

J. E. NANEVICZ and E. F. VANCE (SRI International, Menlo Park, CA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 441-449.

Low-cost laboratory techniques for measuring the corona threshold of an aircraft protuberance are presented. A scale model of the aircraft is used together with a sample of the protuberance in question, and following one measurement on the aircraft model and two on the sample, it is possible to determine the corona threshold of the protuberance as installed on the aircraft. The present technique can aid in the exploration of alternate sites on the aircraft so as to minimize the likelihood of corona discharge. Moreover, it can suggest possible modifications to the protuberance (such as the rounding of edges) which would increase the corona threshold potential. K.K.

A86-47338

ASPECTS OF LIGHTNING PROTECTION SCHEMES FOR RADOMES

J. BISHOP (Royal Aircraft Establishment, Flight Systems Dept., Farnborough, England), A. AKED (Strathclyde, University, Glasgow, Scotland), C. W. POWELL, and H. M. RYAN (NEI Reyrolle, Ltd., Hebburn, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 499-507. Sponsorship: Ministry of Defence. (Contract MOD-A81A/2093)

The feasibility of assessing aircraft radome lightning protection on the basis of lightning striking distance is demonstrated. A radome is simulated by an 8-m (in length) hemicylindrical mock radome while approaching lightning is represented by a 3-m spark; the conductors in and on the radome are earthed. A simple mathematical model describing the protection is derived and experimental results are given. It is concluded that within the bounds of unpredictability of high voltage discharges, the proposed model can explain the performance of a cylindrical case of protective conductors in terms of their pitch and distance from the internal metalwork being protected. K.K.

A86-47485#

EFFECT OF HEAD-UP DISPLAY DYNAMICS ON FIGHTER FLYING QUALITIES

R. E. BAILEY (Calspan Advanced Technology Center, Buffalo, NY) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 743-754. refs (Contract F33615-83-C-3603) (AIAA PAPER 86-2206)

An experimental investigation of head-up display (HUD) symbol dynamic response characteristics on flying qualities using USAF NT-33A aircraft is reported. The Display Evaluation Flight Test system was used to provide the HUD system variations. It was found that a substantial tolerance exists in temporal distortion between the motion and visual response cues which does not apparently affect the pilot, as indicated by flying qualities evaluation. For a constant, Level 1 motion response, there is no effect on flying qualities in an up-and-away flight phase for up to 190 msec delay added to the HUD. Beyond this threshold, flying qualities degrade by approximately 1.75 pilot ratings per 100 msec added to the display. For the power approach task and a Level 1 motion response, no effect on flying qualities occurs for up to 310 msec delay added to the display. Beyond this threshold, flying qualities degrade by about 1.95 pilot ratings per 100 msec added. C.D.

A86-47636* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

RECENT ADVANCES IN MONTE CARLO TURBULENCE SIMULATION

C. W. CAMPBELL and G. H. FICHTL (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Conference on Aerospace and Range Meteorology, Huntsville, AL, August 27-29, 1985, Proceedings . Boston, MA, American Meteorological Society, 1985, p. 65-68. refs

The purpose of Monte Carlo turbulence simulation is to add statistically accurate 'bumps' to aerospace vehicle flight simulation. Several recent improvements in the state of the art are reviewed and classified according to various characteristics affecting the realism of the simulation. Areas for future research are made clear by the classification scheme. Author

A86-47704*# Integrated Systems, Inc., Palo Alto, Calif.

A STUDY OF AIRCRAFT CRUISE

P. K. A. MENON (Integrated Systems, Inc., Palo Alto, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 518-532. refs (Contract NAS2-11978) (AIAA PAPER 86-2286)

The long range aircraft cruise problem is analyzed using a model intermediate in complexity between energy model and point mass model. It is shown that this formulation imbeds the classical steady state cruise as the central member along with several other oscillatory extremals. The oscillatory cruise trajectories are shown to exist if the Hessian of the function QD/VT with respect to altitude and airspeed is positive definite. An expression for predicting the frequency of oscillation is developed. Qualitative effects of increasing the vehicle thrust and improving the L/D are discussed. Numerical results for two fighter aircraft and a transport aircraft are given. While oscillatory cruise mode exists for the two fighter aircraft, steady state cruise at full throttle is found to be optimal for the transport aircraft. A second variation analysis to bring out the reason for fuel savings is developed. It is shown that whenever the Hessian of the function QD/VT is positive definite, the second variation will be zero along the classical steady state cruise arc, indicating that a neighboring extremal is competitive. Comparisons with the previous point mass and energy modeled results are given. Author

A86-47705* Stanford Univ., Calif.

OPTIMAL LANDING OF A HELICOPTER IN AUTOROTATION

A. Y. LEE, A. E. BRYSON, JR., and W. S. HINDSON (Stanford University, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 533-541. refs

(Contract NCC2-106)

(AIAA PAPER 86-2287)

The landing of a helicopter in autorotation is formulated as a nonlinear optimal control problem. A unique feature in the present formulation is the addition of path inequality constraints on both the control and the state vectors. The control variable inequality constraint is a reflection of the limitation on the rotor thrust coefficient. The state-variable inequality constraint is an upper bound on the vertical sink-rate of the helicopter during descent. Optimal trajectories are calculated for entry conditions well within the height-velocity (H-V) restriction curve, with the helicopter initially in hover or in forward flight. The optimal solutions exhibited control techniques similar to those used by helicopter pilots in actual autorotational landings. The study indicates that, subject to pilot acceptability, a substantial reduction could be made in the H-V restriction zone using optimal control techniques. Author

A86-47727

FLOW STAGNATION AS AN ADVANCED WINDBLAST PROTECTION TECHNIQUE

L. J. SPECKER (USAF, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 12-17. refs

A windblast protection device which uses high-strength, deployable fabric panels has been tested. The panels capture and slow the aerodynamic flow impinging on the ejection seat occupant's extremities and torso and reduce the probability of injury caused by windblast. Wind tunnel tests were conducted in low- and high-speed wind tunnels using one-half scale models of a fiftieth-percentile size male crewmember and ejection seat. Measurements taken included forces and moments acting on the crewmember's arms, legs, and head; total forces and moments on the crewmember and seat model; and static pressure on the surface of the crewmember and flow-stagnation panels. Additional tests were accomplished to measure full-scale static aerodynamic coefficients of various flow-stagnation panel configurations. These tests were accomplished with volunteer subjects and a modified ejection seat. This paper reviews the current tests accomplished using the flow-stagnation concept as well as tests utilizing the concept 25 and 45 years ago. Successful application of the flow-stagnation concept is a promising candidate solution to the problem of windblast protection. Author

A86-47728

EVALUATION OF A PRE-EJECTION UPPER TORSO RETRACTION DEVICE

M. P. CONNORS and J. W. BRINKLEY (USAF, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 18-23. refs

Laboratory tests have been conducted to determine the performance of powered retracting inertia reels. Sixteen tests to study the basic operating properties of the inertia reels were accomplished by using the reels to lift masses over varied distances. After completion of a test with an anthropometric dummy, 37 tests were performed using 6 volunteer subjects. Retraction distances of 2, 4, 6, 10, and 14 inches were investigated. Eighteen of the tests with volunteers were accomplished by remote initiation of the reels. For 19 tests the subjects manually initiated the powered reels by pulling on ejection-initiation handles mounted on the sides of the test seat. Data collected include retraction strap load, subject displacement, head and chest accelerations, ejection handle-pull torque and seat contact forces. In 16 of 19 tests where the subject

manually initiated the reel, the retraction time exceeded 300 msec and/or the subjects were not fully retracted. When the reel was remotely initiated, retraction time exceeded 300 msec and/or retraction was incomplete in 3 of 18 tests. These findings and the results of post-test inspections of the reels are discussed.

Author

A86-47733

DEVELOPMENT OF A CONTROLLABLE CATAPULT FOR EJECTION SEATS

J. M. PETERS and J. A. HUBERT (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 64-68.

It has been demonstrated that the performance of an ejection seat catapult can be controlled by using multiple propellant charges and selective venting of the propellant gases. The purpose of this paper is to present a brief overview of the development of the controllable ejection seat catapult (CESC) and to examine the results of the test program. Fourteen full scale tests of the CESC were conducted over a temperature range of -65 F to +165 F, for a payload range of 313 lb to 437 lb and at imposed g levels of -3, 0 (static), +4 and +7. Operation of the catapult is controlled by a microprocessor control system which initiates firing of two propellant cartridges and the operation of four shuttle valves in the catapult base to vent gases. The control law employed is designed to limit DRI to a value of 16 while maximizing strip-off velocity. A successful easy ride test was conducted which limited the DRI to a value less than 10. Author

A86-47736

RETROFIT ENERGY-ABSORBING CREWSEAT FOR THE SH-3 (S-61 SERIES) SEA KING HELICOPTER

R. E. ZIMMERMANN (Simula, Inc., Phoenix, AZ) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 76-80.

A86-47743

MACH NUMBER IMMUNE MICROPROCESSOR CONTROLLED SEQUENCER FOR OPEN EJECTION SEATS USING ON-BOARD ENVIRONMENTAL SENSORS

W. R. PECK (Stencel Aero Engineering Corp., Asheville, NC) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 133-136.

A86-47757

SENSOR SELECTION FOR THE BOEING CREST EJECTION SEAT DESIGN

A. K. TRIKNA (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 238-243. refs

The ejection seat design being developed under the Crew Escape Technologies 'CREST' program will enable the seat to be stabilized in all three axes and meet stringent low altitude performance requirements, without subjecting the crewmember to excessive accelerations. The implementation of the associated ejection seat control law requires measurements of various parameters such as linear accelerations, angular rates, altitude above ground, dynamic pressure, etc. Various sensors are available to provide these measurements. However, these must be selected and packaged properly to achieve an efficient ejection seat design. This paper provides an overview of the sensor package selected for the Boeing CREST seat design. The discussion includes the basic sensors and the procedure used for selecting the best sensor package. Author

A86-47758

BOEING CONTROL LAW FOR CREST DEMONSTRATION EJECTION SEAT

A. K. TRIKNA and K. S. DUFFY (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 23rd, Las Vegas, NV, December 1-5, 1985, Proceedings. Van Nuys, CA, SAFE Association, 1986, p. 244-249. refs

The expanding aircraft performance envelopes of current and future high performance military aircraft exceed the capabilities of current ejection seats which have inadequate stability, fixed performance levels, and no provisions for trajectory modification to adjust for prevailing conditions at the time of ejection. This paper presents an overview of the Boeing adaptive ejection seat control law, developed under the Crew Escape Technologies 'CREST' program, which addresses these needs. The key features of the Boeing control approach are discussed. Simulation results are presented to show that the Boeing control law, together with the CREST propulsion system, stabilizes the seat, meets low altitude performance requirements, and satisfies crewmember acceleration limits for all design ejection conditions. A brief comparison is also made with the performance of an alternative ejection seat control law developed under another USAF contract.

Author

A86-47768#

ANTHROPOMETRIC CONDITIONS FOR THE CONSTRUCTION OF A HELICOPTER COCKPIT [ANTHROPOMETRISCHE VORGABEN FÜR DIE KONSTRUKTION EINES HUBSCHRAUBER-COCKPITS]

G. KROH (Luftwaffe, Flugmedizinisches Institut, Manching, West Germany) IN: Evaluation of man-machine systems: Methods and problems; Symposium, November 14, 15, 1985, Cologne, West Germany, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 10-24. In German.

Helicopter pilots were used to test the dummy cockpit of a helicopter now under development in order to develop a data base for the seating and the steering organs. Seated tests showed that the postures assumed by the pilots during flights generally did not agree with those envisioned in the construction specifications. This was due to the relatively large discrepancy in arm length between the 5th and the 99th percentile. To prevent their arms from getting tired, the pilots pushed the seat back farther than expected by the designer. Suggestions are also briefly made for the location of the stick and pedals.

C.D.

A86-47776

SOCIETY OF FLIGHT TEST ENGINEERS, ANNUAL SYMPOSIUM, 16TH, SEATTLE, WA, JULY 29-AUGUST 2, 1985, PROCEEDINGS

Symposium supported by the Boeing Co. Lancaster, CA, Society of Flight Test Engineers, 1985, 292 p. For individual items see A86-47777 to A86-47802.

The present conference on advancements in flight testing methods encompasses topics in test technology development, noteworthy flight test results, the management of test flight programs, the current status of numerous flight test programs, and the state-of-the-art in data-gathering and test instrumentation systems. Attention is given to flight testing of the Tornado terrain-following radar system in bad weather, of high bypass turbofan engines, and of the ground effect behavior of a powered lift STOL aircraft during landing approach. Also noted are the management of software-intensive systems testing, the merits of customer vs. contractor flight testing, precise control surface position measurements for hysteresis and twist bending, an avionics digital data acquisition system, a portable airborne digital data system, inflight loads in existing transport aircraft, flight simulator testing, and flight flutter testing.

O.C.

A86-47777

A PROPOSED PLANE FOR THE INITIAL FLIGHT TESTING OF A RUTAN AIRCRAFT FACTORY LONG-EZ AND OTHER LIGHT AMATEUR EXPERIMENTAL AIRCRAFT

W. J. NORTON (USAF, Wright-Patterson AFB, OH) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 1.1-1 to 1.1-11. refs

The FAA requires 40 hours of flight testing for amateur experimental aircraft before registration and permission for passenger carriage. Although there is no need to comply with specific airworthiness of performance specifications, the builder/pilot should perform certain flight tests to ensure proper control, performance levels, and systems' functioning. Attention is presently given to flight test method objectives, maneuvers, data recording techniques, and data analyses for this type of aircraft.

O.C.

A86-47779

FLIGHT TESTING IN THE AIRCRAFT CARRIER ENVIRONMENT

C. P. SENN (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 1.3-1 to 1.3-9.

A comprehensive account is given of the systems and operational steps involved in takeoff and landing flight test operations aboard a Nimitz-class aircraft carrier, as undertaken by F-14A and F/A-18A aircraft. Attention is given to the carrier deck layout, steam catapult systems and their hook-up with aircraft, the landing arresting gear, structural and jet blast deflector tests, minimum launch airspeed criteria, and optimum landing approach angle-of-attack/airspeed criteria.

O.C.

A86-47781* National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

FLIGHT TEST EXPERIENCE AND CONTROLLED IMPACT OF A LARGE, FOUR-ENGINE REMOTELY PILOTED AIRPLANE

R. W. KEMPEL and T. W. HORTON (NASA, Flight Research Center, Edwards, CA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 2.1-1 to 2.1-14. Previously announced in STAR as N85-33123.

A controlled impact demonstration (CID) program using a large, four engine, remotely piloted transport airplane was conducted. Closed loop primary flight control was performed from a ground based cockpit and digital computer in conjunction with an up/down telemetry link. Uplink commands were received aboard the airplane and transferred through uplink interface systems to a highly modified Bendix PB-20D autopilot. Both proportional and discrete commands were generated by the ground pilot. Prior to flight tests, extensive simulation was conducted during the development of ground based digital control laws. The control laws included primary control, secondary control, and racetrack and final approach guidance. Extensive ground checks were performed on all remotely piloted systems. However, manned flight tests were the primary method of verification and validation of control law concepts developed from simulation. The design development, and flight testing of control laws and the systems required to accomplish the remotely piloted mission are discussed.

Author

A86-47782

FLIGHT TESTING A TRANSSONIC WING WITH MANEUVER FLAPS AND A DIRECT SIDE FORCE CONTROL SYSTEM FOR CAS AIRCRAFT

U. VON MEIER, H. BUERS, H. WUENNEBERG, J. LANG, D. THOMAS (Dornier GmbH, Friedrichshafen, West Germany) et al. IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 2.2-1 to 2.2-11. refs

Two experimental flight test programs have been conducted for Alpha Jet Transonic Test Wing and Direct Side-Force Control (DSFC) development; attention is presently given to the wing and

control surface design features of the modified Alpha Jets used in these test programs and to the test methods employed. Comparisons are made with wind tunnel test results and instrumentation hardware; substantial maneuverability and performance efficiency improvements are noted. The results obtained from Transonic Test Wing and DSFC flight testing are applicable to the design of future transonic combat aircraft. O.C.

A86-47783

FLIGHT TESTING OF THE TORNADO TERRAIN FOLLOWING RADAR SYSTEM IN BAD WEATHER

D. SEECK (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 2.3-1 to 2.3-6.

An account is given to the system features and flight test methods and results of the Tornado Interdiction Strike Aircraft version's Terrain-Following/Autopilot and Flight Director System (TF/AFDS). In the course of seven years, 200 TF/AFDS development flights have been conducted in order to achieve the requisite ultralow clearance height for Mach 0.9 flight, over mountainous terrain, in full instrument-flight-rules meteorological conditions. Attention is given to the effects of topography, weather, crew training, cockpit controls, monitoring tasks, and crew workloads. O.C.

A86-47784* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE GROUND EFFECTS OF A POWERED-LIFT STOL AIRCRAFT DURING LANDING APPROACH

V. C. STEVENS (NASA, Ames Research Center, Moffett Field, CA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 2.4-1 to 2.4-10. refs

Attention is given to the ground proximity effects of a powered lift STOL aircraft, NASA's Quiet Short Haul Research Aircraft (QSRA); these effects have a profound influence on a landing's touchdown dispersion and sink rates, and must be determined with the greatest possible accuracy. The QSRA flight parameter values obtained by means of a small perturbation model for the trim flight condition out of ground effect, during a landing approach, are compared with flight test values, on the premise that any discrepancies between the two sets of values will be due to ground effect. O.C.

A86-47785

F-14A LOW-ALTITUDE ASYMMETRIC THRUST SIMULATION AND FLIGHT TEST PROGRAM

P. CONIGLIARO (Grumman Aerospace Corp., Bethpage, NY) and W. STILES IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 2.5-1 to 2.5-6.

A low altitude asymmetric engine thrust flight test program has been conducted for the F-14A aircraft in order to determine the low speed/low altitude flight envelope in which asymmetric thrust characteristics are most critical. Piloted simulation was used extensively, and aerodynamic and mathematical models for asymmetric thrust-induced departures were updated to improve simulation fidelity; the results of subsequent piloted simulations defined the critical departure boundaries for demonstration maneuvers that could be safely performed. Maneuvers were performed down to 10,000 ft, and to near-spin angles-of-attack (in excess of 60 deg), to verify simulation results. O.C.

A86-47787

RESULTS OF TECHNOLOGY PROGRAMS FOR GENERAL AVIATION AIRCRAFT AT DORNIER

H. MAX (Dornier GmbH, Friedrichshafen, West Germany) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 3.6-1 to 3.6-12. refs

Attention is given to the component design features, data gathering techniques, and results of three aerodynamics/flight mechanics-related flight test programs associated with general aviation aircraft development. These programs concerned the development of a new-technology wing, an advanced propeller blade, and a gust alleviation control surface system. Flight test results have been compared with performance data for comparable conventional counterparts; it is demonstrated that the new techniques improve the performance, economics, and passenger comfort of general aviation aircraft. O.C.

A86-47789

PRECISE CONTROL SURFACE POSITION MEASUREMENTS FOR HYSTERESIS AND TWIST TESTING

B. J. LAPLACA and F. PARLINI (Boeing Commercial Airplane Co., Seattle, WA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 4.3-1 to 4.3-5.

Testing was conducted to evaluate elevator twist at several spanwise stations during flight and to measure elevator control system hysteresis on the ground and in cruise flight. Maneuvers conducted include stabilizer elevator trades, wind-up turns and elevator doublets. The effects of hysteresis on autopilot performance were documented at reduced stability flight conditions. The testing included flying at cruise Mach with the center of gravity as far aft as the maneuver point. To provide adequate flight test data, new instrumentation hardware, installation and calibration techniques were utilized. This included using synchros for measuring surface positions and the evaluation of two new types of installation hardware. The synchros provided much better accuracy with less hysteresis than the potentiometers that were previously used. Two calibration techniques were tried; the one finally used is very accurate but also time consuming. Author

A86-47793

RE-ENGINE KC-135R/CFM56 FLIGHT TEST PROGRAM - AN OVERVIEW

R. E. HART (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 5.2-1 to 5.2-6.

A Combined Test Team recently completed a flight test program on a KC-135A modified to a re-engined KC-135R configuration. The problem existing was that the KC-135A, introduced in the mid-1950s, presently has performance limitations, logistic support problems, and high ownership costs. The objective of the test program was to evaluate a re-engined KC-135R as an option to alleviating these problems. The primary modification consisted to replacing the J57 engines with high bypass CFM56-2B-1 turbofan engines. The preliminary flight test evaluation encompassed 55 flights, over a period of approximately six months. The results showed a significant improvement in takeoff, climb, and level flight performance over that of the KC-135A model. The result of the re-engine on fuel consumption was an increase in specific range of approximately 25 percent over the KC-135A range. Problem areas caused by the modification were minor in nature. Based on part on results of this test program, contracts have been let for the re-engining of additional KC-135A airplanes. This paper addresses the re-engine modification, test program, results and conclusions, as well as problems and their resolution. Author

A86-47794

A NEW LOOK AT INFLIGHT LOADS ON EXISTING TRANSPORT AIRCRAFT

T. C. CASTONA (Lockheed-Georgia Co., Marietta) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 5.3-1 to 5.3-10.

The Severe Missions Loads Recording Programs for the C-130 and C-141 cargo aircraft have yielded much data on the actual severity of mission loadings relative to airframe structural strength. Attention is given to the results of analyses of the C-130's loads. It is noted that while the design limit load was not reached during any of the severe mission flights, the gust and maneuver exceedance spectra obtained did not reflect current criteria for some mission types. A unit load analysis shows general agreement between measured and analytical loads. O.C.

A86-47795

X-29 TECHNOLOGY DEMONSTRATOR PROGRAM STATUS REVIEW

W. CUTLER (Grumman Aerospace Corp., Bethpage, NY) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 5.4-1 to 5.4-10.

An evaluation is made of the flight test method advancements, and flight test results to date, of the X-29 forward swept wing advanced technology demonstrator program. Attention is given to the X-29 test program structure, preflight aircraft/test team preparations by means of a simulator, and the design features that the X-29 will subject to rigorous testing. A C-131 Total In-Flight Simulator vehicle was linked to an Automated Telemetry Station in the initial stage of the program, testing and training both the flight test engineering team and prospective pilots for failure situations. O.C.

A86-47796

T-46A - THE USAF NEXT GENERATION TRAINER

F. S. BROWN (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 5.5-1 to 5.5-5.

The Fairchild T-46A will replace the Cessna T-37B as the United States Air Force (USAF) primary training aircraft. The T-46A will present the USAF Air Training Command (ATC) with a number of advantages relative to the T-37B. The T-37B airframes are approaching the end of their useful life. The T-46A will have a 20,000 hour structural life. Garrett F109 turbofan engines in the T-46A will have significantly better fuel consumption and noise characteristics than the J69 turbojets used in the T-37B. The T-46A will also feature cockpit pressurization and a limited anti-ice capability. Advantages which will permit ATC to train in the less crowded skies above 25,000 feet. A 22 month flight test program at Edwards AFB is planned in support of a November 1987 operational capability. Air Force procurement of 650 T-46A aircraft is anticipated. Author

A86-47797

AIRBUS A 320 - NEW CONCEPT OF AIRCRAFT CONTROL

G. GUYOT (Airbus Industrie, Toulouse, France) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 5.6-1 to 5.6-6.

Attention is given to the design features of a novel flight control system that will be implemented for the first time in the A320 airliner. This Electric Flight Control System (EFCS) will furnish improved stall and windshear protection, 200-kg weight savings in both control hardware and the A320's wing structure through load alleviation, improved handling, and reduced production and maintenance costs. The EFCS' most direct effect on cockpit design will be the substitution of a sidestick controller for the conventional control column. O.C.

A86-47799

THE INS WIND CALIBRATION IN CLIMB ALGORITHM

D. K. TIPPEY (McDonnell Aircraft Co., Saint Louis, MO) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 6.2-1 to 6.2-6.

Because the AV-8B Departure Resistance program was conducted without a flight test noseboom, INS-derived angle of attack (AOA) and angle of sideslip (AOSS) were the primary sources of angular information. Because the winds aloft must be known in order to calculate INS AOA and AOSS, and because a departure or spin may result in a significant altitude loss, a new INS winds aloft algorithm had to be developed. This so-called 'wind calibration in climb' algorithm allowed the mapping of winds aloft as a function of altitude during the initial climb to test altitude. This was an improvement over the older 'straight and level' winds aloft method because it allowed for altitude effects and reduced the amount of flight time dedicated to gathering wind data. Author

A86-47800* DEI-Tech, Inc., Newport News, Va.

FLIGHT TESTS AND PRELIMINARY AERODYNAMIC PARAMETER EXTRACTION OF AN EXTERNALLY PILOTED VEHICLE AIRCRAFT MODEL

E. R. WHITE, M. T. MOUL, and A. C. EDWARDS (DEI-Tech, Inc., Newport News, VA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 6.4-1 to 6.4-7. refs

(Contract NAS1-17686)

Model aircraft flight test investigations have been undertaken to develop a low cost flight data acquisition system and to evaluate aerodynamic parameter estimation techniques. The externally piloted vehicles (EPVs) used are instrumented with sensors measuring acceleration, angular rates, angles of attack and sideslip, flight path velocity, and control deflections. Measured state variables are downlink telemetered to a ground-based real time flight data acquisition system; the data thus recorded are used by flight test engineers and EPV pilots to monitor conditions and aid in piloting tasks. Attention is given to comparisons of F-16 EPV data with wind tunnel data. O.C.

A86-47801

QUANTIFYING A PROPELLER/ENGINE POWER RESPONSE RATE MISMATCH

D. J. NELSON (Veda, Inc., Lexington Park, MD) and K. J. HUBLEY (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 6.5-1 to 6.5-7. Research supported by the Grumman Aerospace Corp., General Motors Corp., United Technologies Corp., and U.S. Navy.

The Naval Air Systems Command directed the Naval Air Test Center in cooperation with Allison, Grumman and Hamilton Standard Corporations to investigate the causes of an unsolicited RPM decay, known as 'Bogdown', on the T56-A-425 engine installed on the E-2C aircraft and evaluate potential fixes. The resulting study necessitated the development of a data reduction technique to quantify a major cause of bogdown, namely the propeller/engine power response rate (PEPRR) mismatch. This paper discusses the methods attempted and shortcomings of classical data reduction techniques and presents a derivation of an instantaneous change in angular momentum analysis which proved very useful in understanding the bogdown phenomena. Author

A86-47802* National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

FLIGHT FLUTTER TESTING AT AMES-DRYDEN

L. R. FELT and M. W. KEHOE (NASA Flight Research Center, Edwards, CA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 6.6-1 to 6.6-36. refs

Over the past several years the NASA Ames-Dryden Flight Research Facility at Edwards Air Force Base has developed a variety of flight flutter and ground test techniques which have been applied to an assortment of new or modified aerospace research vehicles. This paper presents a summary of these techniques and the experiences gained from these applications. Topics discussed include the roles of ground vibration testing, flight flutter testing, wind tunnel flutter model testing, predictive analyses, and aeroservoelastic considerations. Data are presented for a wide variety of aircraft, including remotely piloted vehicles, modern fighters with relaxed static stability and highly augmented flight control systems, aircraft modified for laminar flow control experiments, a glider modified for deep stall tests, and aircraft with skewed or forward swept wings. The conclusions include a brief discussion of future directions in flight flutter testing at Ames-Dryden.

Author

A86-48184#

CFD FOR ENGINE-AIRFRAME INTEGRATION

G. C. PAYNTER, C. K. FORESTER, and E. TJONNELAND (Boeing Military Airplane Co., Seattle, WA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 10 p. refs
(ASME PAPER 86-GT-125)

This article provides an assessment of current CFD technology with application to propulsion integration, a definition of the areas in CFD technology where research and development will extend the technology, and a discussion of numerical error assessment and control. The CFD technology is divided into the elemental areas of the computer system, algorithms, geometry and mesh generation, turbulence modeling, and experimental validation; the current status and major issues in each of these areas are defined. Sources of numerical error are identified and some strategies for determining and controlling these are presented. CFD will have an impact on propulsion integration equivalent to that of the wind tunnel as CFD technology matures. This maturation will lead to a system which integrates the elemental areas of CFD for applications.

Author

A86-48308#

AIRCRAFT/ENGINE INTEGRATION FOR AN ADVANCED FIGHTER CONSIDERING MISSION SPECIFICS

G. RAUH and W. ANDERS (Messerschmitt-Boelkow-Blohm GMBH, Munich, West Germany) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 9 p.
(ASME PAPER 86-GT-295)

In this paper propulsion system integration is considered for an advanced twin-engined, high-performance agile air-to-air fighter aircraft in view of its requirements for extreme flight conditions and maneuvers. The propulsion system mainly consists of air inlets, engines and nozzle/afterbody systems. The air inlet is physically well integrated with the aircraft flight control system, processing hardware being part of it. The engine itself must have very simple and clearly defined interfaces with the aircraft. Its integration must therefore be functional. A central utility data bus allows for easy communication between the engine control system and all relevant aircraft systems through a single point interface in normal operation. This improved communication allows for better performance, operation and handling of the engine. A special feature of the propulsion system is the vectoring nozzle system with thrust deflection for maneuvers at high angles of attack beyond maximum lift. This system is also integrated with the flight control systems.

Author

A86-48370

CAN EUROPE MEET THE CHALLENGE OF LHX?

M. LAMBERT Interavia (ISSN 0020-5168), July 1986, p. 741-744.

Four major national and international programs are under way in western Europe to produce military helicopter technology comparable to that currently under development for the U.S. Army's LHX program: the British EH 101, the French/German HAP/HAC/PAH-2, the British/German/Italian/Dutch NH-90, and the British/Italian/Dutch/Spanish A.129 'Tonal'. Attention is presently given to airframe materials, avionics capabilities, propulsion systems components such as transmissions and rotor hubs, and weapons suites.

O.C.

A86-48467

DYNAMIC RESPONSE OF THE A.310 IN FLIGHT TO CONTROL-SURFACE LOADING [REPOSE DYNAMIQUE DE L'A.310 EN VOL A DES SOLlicitATIONS DE GOUVERNES]

J. GROUAS (Aérospatiale, Toulouse, France) Association Aeronautique et Astronautique de France, Colloque d'Aérodynamique Appliquée, 22nd, Lille, France, Nov. 13-15, 1985. 15 p. In French.

(AAAF PAPER NT 85-18)

Experimental flight results obtained in 1984 with the A.310 No. 172 aircraft on the unsteady effects of the control surfaces verify the proposed model for the analysis of aircraft active control. The model is composed of a structural part incorporating terms of inertia, damping, and aeroelasticity, and an aerodynamic part consisting of forces of motion and forces of deflection. Good agreement is found between theoretical results and experimental results obtained in the wind tunnel and in flight.

R.R.

A86-48468

IDENTIFICATION OF UNSTEADY RESPONSE IN RUDDERS AT LOW VELOCITIES [IDENTIFICATION DE LA REPOSE INSTATIONNAIRE DE GOUVERNES AUX BASSES VITESSES]

J. VERRIERE (Toulouse, Centre d'Essais Aeronautiques, France) and C. COUEDOR (Avions Marcel Dassault-Breguet Aviation, Vaucresson, France) Association Aeronautique et Astronautique de France, Colloque d'Aérodynamique Appliquée, 22nd, Lille, France, Nov. 13-15, 1985. 43 p. In French.

(AAAF PAPER NT 85-19)

Two test trials performed on a Mirage 4000 mockup equipped with an oscillation mechanism for the canard rudders have validated the performance of the CEAT wind tunnel with two degrees of freedom in identifying the longitudinal and unsteady aerodynamics coefficients. Problems of the wind tunnel include the limited accuracy of the accelerometric measurements and the effects of inertia resulting from the mechanism's oscillation. Advantages of the present testing method include its low cost, and the derivation of global coefficients in short testing times.

R.R.

A86-48576#

INTERIOR TRANSITION LAYERS IN FLIGHT PATH OPTIMIZATION

M. D. ARDEMA (Santa Clara, University, CA) and L. YANG (Sterling Software, Inc., Palo Alto, CA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 9 p. refs

(AIAA PAPER 86-2037)

Interior transition layers occur in flight path optimization by singular perturbation methods whenever the reduced solution exhibits multiple branches. Although such phenomena occur in many problems, it has been little studied in the literature. In this paper, we consider interior transition layers in vertical-plane climb-path optimization. Our approach is to treat the interior layer associated with the transonic energy-state discontinuity as two boundary layers, one in forward and one in backward time. The initial states of the two boundary layers are matched to give continuous composite solutions at the point of reduced solution discontinuity.

Author

A86-48594

MEASUREMENTS AND COMPUTER MODELLING OF ENGINE EXHAUST NOISE IN THE CABIN OF SINGLE-ENGINE AIRCRAFT

A. J. CAMPANELLA (ACCULAB, Columbus, OH) IN: NOISE-CON 85 - Computers for noise control; Proceedings of the National Conference on Noise Control Engineering, Columbus, OH, June 3-5, 1985. New York, Noise Control Foundation, 1985, p. 273-278. refs

Research is reported on the problem of cabin noise in single-engine aircraft, noting that noise levels near the pilot's head is often 88 to 93 dBA - levels that are uncomfortable, interfere with speech communications, and indicate that hearing protection should be worn. Earlier data consisting of third-octave band noise spectra, recorded from microphone locations inside and outside an aircraft, are plotted. A long tailpipe, added to shunt exhaust noise aft during noise reduction experiments, was found to reduce not only the external noise in the forward aircraft areas but also the interior noise in the forward cabin. Additional noise in the 80-Hz third-octave band was presumed to be due to the propeller (2500 rpm, 2 blades). A branch resonator, short tailpipe and long tailpipe were evaluated under climb, cruise and slow cruise conditions. The A-weighted spectral level was computed and plotted to aid in the evaluation of noise reduction treatments. A short tailpipe extension was also tested on a second aircraft. The exhaust treatments are seen to provide less noise reduction at high power settings than at low power. O.C.

A86-48657

COMPUTING CODES FOR DEVELOPMENT OF HELICOPTER CRASHWORTHY STRUCTURES AND TEST SUBSTANTIATION

J. MENS (Aerospatiale, Marignane, France) and J. C. BIANCHINI (Engineering System International, Rungis, France) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 2. Alexandria, VA, American Helicopter Society, 1985, 13 p. refs (Contract DRET-79-436)

Helicopter airframe structures must be designed to absorb energy in the course of a crash in such a way as to maintain the acceleration of passengers and crew at a level that can be tolerated by the human body. Attention is presently given to a stress analysis and prediction method which yields the buckling and postbuckling characteristics of elements subjected to large deformations. This method's computer code, 'KRASH', is an incremental numerical calculation program describing the movement of N masses that are interconnected by deformable elements represented by a rigidity matrix. O.C.

A86-48659

PROGRAM SYSTEM OF COMPUTER-AIDED DESIGN OF HELICOPTER ROTOR BLADE AIRFOIL

Y.-X. XU (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 6 p. refs

The Xu and Chang (1978, 1981) airfoil design equations for a tapered and twisted helicopter rotor blade with two known sections are presently extended and computer-implemented in order to generate an integral mold for the production of the Y-2 helicopter's fiberglass-reinforced plastic rotor blades. The mold is machined according to the computer code by means of numerically controlled tools. The mold is already in use and is characterized by high production efficiency. O.C.

A86-48660

THE PHYSICAL UNDERSTANDING ON HELICOPTER AIR AND GROUND RESONANCE

X.-G. ZHANG (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 24 p. refs

The physical explanations of helicopter air and ground resonance are studied with complex multiblade coordinate for a two-dimensional 4 degree-of-freedom ground resonance model and a 6 degree-of-freedom air resonance model without aerodynamics. In each case, both longitudinal and lateral symmetrical condition and unsymmetrical condition are considered in the step-by-step analysis. The occurrence of instability can be fully explained by the mode shape and the mutual influence of rotor lead-lag motion and body motion. In the symmetrical air resonance, only the coupling of regressive lead-lag mode and gyroscopic mode can induce instability. Only in the unsymmetrical air resonance, the regressive lead-lag mode can be coupled with the regressive flapping mode and induce instability. Author

A86-48662

NUMERICAL ANALYSIS OF AEROELASTIC STABILITY PROBLEM OF HELICOPTER ROTOR BLADE

H. DAI, S. ZHOU, and G. XU (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 13 p. refs

The Broyden-Newton algorithm is a combination of the Broyden-Rank-1 and Newton algorithms for solving nonlinear equations. The Broyden-Newton algorithm and combination QZ method are applied to a study of the aeroelastic stability problem of helicopter rotor blade. The practices of computations indicate that they are effective methods by which the aeroelastic stability problem of helicopter rotor blade is analyzed numerically. Author

A86-48663

DYNAMIC ASPECTS IN THE DESIGN OF ADVANCED ROTOR SYSTEMS

G. REICHERT (Braunschweig, Technische Universitaet, Brunswick, West Germany) and H. HUBER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 19 p. refs

Attention is given to the dynamic characteristics of composite and combined composite/elastomeric helicopter rotor systems, which exhibit pronounced structural/dynamic coupling effects that substantially influence the aeromechanical characteristics of the helicopter. The influence of specific design parameters and the tuning of flexible blades and attachments employing advanced composite materials is isolated. The theoretical results obtained are verified by means of experimental data from component testing, whirl tower tests and full scale flight tests of various advanced main and tail rotors. O.C.

A86-48664

ROTOR AEROELASTIC STABILITY

W.-L. MIAO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 12 p. refs

The aeroelastic and aeromechanical stability problems of the rotor and the coupled rotor-airframe system are reviewed. The interrelationship of the various subcategories of aeroelastic stability is discussed. The key element that influences the rotor aeroelastic stability, namely the spacial location and orientation of the blade pitch axis, is illustrated. Design parameters that enhance the stability characteristics are discussed. Author

A86-48665

COUPLED AEROELASTIC HUB LOADS REDUCTION

J. G. YEN (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 9 p. refs

A theoretical treatment of helicopter hub dynamics is presented which indicates that the interaction of rotor structural properties with airload distributions must be considered in order to minimize hub forcing functions and maintain low vibration levels. The method considers the rotor structural properties of beam, chord, and torsion stiffnesses, as well as span and chord mass distributions. The airload distributions considered are the higher harmonics of span lift and the aerodynamic pitching moment. The theory is presented by simplified rotor dynamics equations. O.C.

A86-48666

ROTOR-FUSELAGE DYNAMIC COUPLING CHARACTERISTICS OF HELICOPTER AIR AND GROUND RESONANCE

R. A. ORMISTON (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 3. Alexandria, VA, American Helicopter Society, 1985, 28 p. refs

An analytical investigation of the air- and ground-resonance characteristics of simplified hingeless-rotor helicopter configurations was undertaken. The objectives were to identify the unique characteristics of low-frequency, coupled rotor-body modes that determine air-resonance stability characteristics, as contrasted to the ground-resonance phenomenon. The study examined the influence of unusual rotor-body modal characteristics, such as nonoscillatory body pitch or roll modes, on air-resonance stability and on the effectiveness of aeroelastic couplings known to suppress air resonance. The results indicate that air-resonance instability does not require distinct coalescences of lead-lag and rotor-body modal frequencies, and unusual rotor-body frequency characteristics do not significantly alter the occurrence of air-resonance instability or the effectiveness of aeroelastic couplings. Air-resonance instability and flap-lag instabilities were found to significantly change character at high rotor speeds for high-Lock number and low-inertia configurations. Author

A86-48667*

IMPLEMENTATION AND VERIFICATION OF A COMPREHENSIVE HELICOPTER COUPLED ROTOR - FUSELAGE ANALYSIS

E. R. WOOD, D. BANERJEE, J. SHAMIE, F. STRAUB, M. A. H. DINYAVARI (McDonnell Douglas Helicopter Co., Culver City, CA) et al. IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 4. Alexandria, VA, American Helicopter Society, 1985, 16 p. NASA-supported research. refs

The analytical basis and the application of a Rotor/Airframe Comprehensive Aeroelastic Program (RACAP) are described in detail. The rationale behind each analytical choice is outlined and the modular procedure is described. The program is verified by application to the AH-1G helicopter. The applicability of various airload prediction models is examined, and both the steady and vibratory responses of the blade are compared with flight test data. Reasonable correlation is found between measured and calculated blade response, with excellent correlation for vibration amplitudes at various locations on the fuselage such as engine, pilot seat, and gunner. Within the analytical model, comparisons are drawn between an isolated blade analysis and a coupled rotor/fuselage model. The deficiency of the former in the context of the AH-1G is highlighted. Author

A86-48668

CALCULATING METHOD FOR Z - 9 HELICOPTERS MOORING LOAD

B. YAN and Q. ZHENG (Harbin Aircraft Factory, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 4. Alexandria, VA, American Helicopter Society, 1985, 13 p.

In the nonlinear FEM presently used to calculate helicopter mooring loads, the mooring cables are simplified into rod elements, while the landing gear's damper struts and wheels are converted into bar elements. Mooring in both adverse weather conditions and on the deck of a rocking ship are considered. Attention is given to wheel parking and inertial loads, wheel friction, and cable loads. O.C.

A86-48672

HANDLING QUALITIES AND FLIGHT PERFORMANCE - IMPLICATION OF THE OPERATIONAL ENVELOPE

A. FAULKNER and W. SINN (Messerschmitt Boelkow-Blohm GmbH, Munich, West Germany) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 5. Alexandria, VA, American Helicopter Society, 1985, 9 p.

The paper discusses the impact of the operational conditions on the subcomponents of helicopters and presents important implications for the layout and design of the aircraft. The substantiation of handling qualities and flight performance at the critical loading (weight, c.g.) and atmospheric (altitude, temperature) conditions is essential. While modern analytical methods are now able to cover the majority of these aspects, however, flight testing is very often mandatory. Various test campaigns with the BK 117 and BO 105 LS helicopters at some of these extreme conditions (altitude up to 22,000 ft, temperatures of -45 to + 50 C) are presented, and the establishment of the operational boundaries is demonstrated. Author

A86-48738* Auburn Univ., Ala.

INVESTIGATION OF THE LEVEL DIFFERENCE BETWEEN SOUND PRESSURE AND SOUND INTENSITY IN AN AIRCRAFT CABIN UNDER DIFFERENT FUSELAGE CONDITIONS

M. S. ATWAL (Paul S. Veneklasen and Associates, Santa Monica, CA), M. J. CROCKER (Auburn University, AL), and K. E. HEITMAN (NASA, Langley Research Center, Hampton, VA) IN: International Congress on Acoustic Intensity Measurement: Measurement Techniques and Applications, 2nd, Senlis, France, September 23-26, 1985, Proceedings. Senlis, France, Centre Technique des Industries Mecaniques, 1985, p. 259-264. NASA-supported research. refs

Problems in using two-microphone sound-intensity (SI) measurements to measure structural transmission losses are investigated in experiments involving light-aircraft fuselage panels and windows. Both sound pressure (SP) and SI are measured near the passenger and door windows and panels of a single-engine aircraft and with these barriers removed, and the effect of increasing interior acoustic absorption and blocking flanking transmission paths is also tested. The results are presented graphically, and the SP measurements are used to indicate frequency ranges in which the two-microphone technique significantly underestimates SI. It is inferred that flanking paths and interior reverberation must be effectively suppressed in order to obtain accurate transmission-loss measurements. T.K.

A86-48759

CALCULATION OF THE LOADING OF THE AIRFRAME IN FLIGHT DUE TO MULTIDIMENSIONAL TURBULENCE [RASHET NAGRUZHENIIA PLANERA SAMOLETA V POLETE OT DEISTVIA MNOGOMERNOI TURBULENTNOSTI]

V. I. TSYMBALIUK TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 1, 1985, p. 69-80. In Russian. refs

A method is proposed for calculating the effect of continuous multidimensional turbulence on the airframe by using a beam diagram of the structure and by expanding the vibrations of the

airframe in eigenmodes. Expressions are presented for the multidimensional spectral densities of the gusts, linear aerodynamic forces and moments, multidimensional frequency characteristics of the loads, load repeatability, and fatigue damage. The loading of the structure is illustrated by using a specific example, and the possibility of using the parameters of a one-dimensional turbulence model is demonstrated. V.L.

A86-48767

SELECTING THE SHAPE OF THE MIDDLE SURFACE OF THE PYLONS AND THE MOUNTING ANGLES OF SINGLE NACELLES UNDER THE WING OF SUBSONIC AIRCRAFT [VYBOR FORMY SREDINNOI POVERKHNOSTI PILONOV I UGLOV USTANOVKI MOTOGONDOL POD KRYLOM DOZVUKOVOGO SAMOLETA]

S. I. SKOMOROKHOV and L. L. TEPERIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 1, 1985, p. 122-125. In Russian. refs

A method is proposed for constructing the middle surface of the pylon-nacelle configuration. Results of wind tunnel tests are presented for a subsonic aircraft model with three versions of the pylon-nacelle design differing in the degree of the deformation of the pylon middle surface. It is shown that a design with an intermediate degree of deformation (about 0.5) has the highest aerodynamic efficiency. V.L.

A86-48805

OSCILLATION EQUATIONS FOR A HELICOPTER ROTOR BLADE [URAVNENIYA KOLEBANIY LOPASTI NESUSHCHEGO VINTA VERTOLETA]

R. A. MIKHEEV and T. D. SMOLIANINOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 3, 1985, p. 127-134. In Russian.

A method is proposed for deriving, in general form, oscillation equations for a helicopter rotor blade. A system of equations is presented in arbitrary coordinates for a blade whose elastic axis is not straight prior to loading. V.L.

A86-48829

A CERTAIN TYPE OF SELF-OSCILLATION OF AIRCRAFT LANDING-GEAR WHEELS [OB ODNOM VIDE AVTOKOLEBANIY KOLES SHASSI SAMOLETA]

V. I. GONCHARENKO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 67-73. In Russian.

A feedback mechanism is established which is responsible for self-oscillations arising during the braking of landing-gear wheels. From the energy point of view, these oscillations (resembling shimmy) are explained by the change in braking forces on the tires. A feedback model is developed, and a qualitative description is given of the nature and conditions of the instability. Oscillation-excitation conditions are examined for a simple wheel arrangement. B.J.

A86-48845

DETERMINATION OF THE REQUIRED STIFFNESS CHARACTERISTICS FOR A LARGE ASPECT RATIO WING FROM THE CONDITIONS OF STATIC STRENGTH AND AILERON EFFICIENCY [OPREDELENIE POTREBNYKH ZHESTKOSTNYKH KHAARAKTERISTIK KRYLA BOL'SHOGO UDLINENIYA PO USLOVIAM STATICHESKOI PROCHNOSTI I EFFEKTIVNOSTI ELERONA]

V. S. VOITYSHEN and V. M. FROLOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 67-79. In Russian.

The optimal design problem for a large aspect ratio wing with constraints on static strength and aileron efficiency is analyzed using an approximate method for determining wing deformations in air flow. Optimal functions for the flexural and torque stiffness of the wing are obtained in the form of piecewise smooth functions. The approach proposed here is demonstrated by an example involving the preliminary design and weight analysis of a wing with typical geometrical parameters. V.L.

A86-48850

MODELING THE ELASTICITY OF A WING STRUCTURE [MODELIROVANIE UPRUGOSTI KONSTRUKTSII KRYLA]

IU. F. IAREMCHUK TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 109-113. In Russian.

The problem considered here is that of identifying the parameters of an elastic model of a wing structure from a given matrix of elastic influence factors. The stiffness parameters of the model are determined from the condition of the minimum of a quadratic functional characterizing the difference between the unknown and given parameters. The necessary conditions of optimality are obtained, and the parameter identification problem is illustrated by an example. V.L.

A86-48978#

AEROELASTICITY TODAY AND TOMORROW

G. COUPRY (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 16-24. refs (ONERA, TP NO. 1986-105)

Research on the aeroelastic design of aircraft and aircraft components is summarized in a survey covering the period 1970-1985. Topics examined include computational approaches to structural design, ground vibration tests, unsteady aerodynamics, wind-tunnel and flight tests, the impact of active control, aeroelasticity of helicopters, and compressor aeroelasticity. Diagrams, photographs, and graphs of typical results are provided, and it is shown that progress in the aeroelasticity of engines and helicopters presently lags behind that on structures. T.K.

A86-48984#

INFLUENCE OF EFCS-CONTROL LAWS ON STRUCTURAL DESIGN OF MODERN TRANSPORT AIRCRAFT

M. BESCH and C. L. TANCK (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 86-96. refs

The effects of electric-flight-control-system (EFCS) control laws on aircraft loading are examined, summarizing the results of an experimental investigation of loading on the horizontal tailplane of a transport aircraft (Tanck and Besch, 1985). The data are presented graphically and characterized, and the implications for aircraft certification regulations are considered. It is found that the tailplane load is less sensitive to maneuver frequency in the EFCS aircraft than in a conventional aircraft, the load increase becoming relatively independent of frequency as frequency increases. The need for careful preflight analysis of the load effects of varying control-law gains and time constants is stressed. T.K.

A86-48985#

747 MODERNIZATION

R. A. DAVIS (Boeing Commercial Airplane Co., Seattle, WA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 97-107.

The modifications being introduced in the 400 series of B-747 passenger aircraft (first deliveries planned for late 1988) are characterized and illustrated with drawings, diagrams, graphs of predicted performance, and photographs. The developmental history of the B-747 is reviewed, and the performance requirements posed by the air carriers are discussed. Modifications described include advanced high-bypass turbofan engines with full-authority digital controls, new nacelles and struts, a 3090-kg weight reduction achieved by using higher-strength Al alloys and structural carbon brakes, improved aerodynamics (wing-tip extension, winglets, and wing/body fairings), an optional 12,490-liter fuel tank in the horizontal stabilizer to increase the range by up to 350 n mi, a quick-change flexible-configuration interior, a two-crew-member flight deck with advanced avionics, and a significant reduction in the number of avionics LRUs. The B-747-400 is designed to have

range 7100 n mi when carrying 412 passengers plus baggage.

T.K.

A86-48986#

APPLICATIONS OF COMPUTER-AIDED ENGINEERING TO SUBSONIC AIRCRAFT DESIGN IN A UNIVERSITY ENVIRONMENT

C. BIL (Delft, Technische Hogeschool, Netherlands) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 108-118. refs

The Aircraft Design and Analysis System (ADAS), a pilot system for computer-aided conceptual aircraft design developed at the Delft University of Technology, is introduced. ADAS is a university contribution to the evolution of aircraft-design computerization. Application of design systems for configuration development improves the efficiency and effectiveness of the design process and potentially results in improved design quality. ADAS is based on the philosophy that a computer-aided-engineering system should incorporate the advantages of computer assistance in design while retaining the flexibility of traditional design. This paper presents a general overview of ADAS and highlights specific components and features, illustrated with examples. Author

A86-48990#

WIND INFLUENCE ON THE RANGE OF JET OR PROPELLER AIRCRAFT

J. F. ELASKAR (Cordoba, Universidad Nacional, Argentina) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 149-152.

The range of jet or propeller aircraft subject to head or tail winds is investigated analytically. It is shown that the range is maximized when the aircraft flies so as to obtain at all times a lift coefficient which satisfies an expression (different for jet and propeller aircraft) relating it to the lift coefficient in still air and the aircraft and wind velocities. The fifth-degree equations for the approximate optimum airspeed are derived and solved numerically, and some typical results are presented in tables. It is found that flying a variable-lift-coefficient method is advantageous in head winds (despite the fact that the range improvement is negligible), because the flight time is decreased relative to constant-lift-coefficient flight. T.K.

A86-48995#

A REVIEW OF UNCONVENTIONAL AIRCRAFT DESIGN CONCEPTS

R. H. LANGE (Lockheed-Georgia Co., Marietta) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 191-200. refs

The need for improved aircraft performance and efficiency has provided the motivation for consideration of unconventional design concepts for aircraft envisioned for operation in the 1990-2000 time period. Advances in technology permit continuing improvements in aircraft performance and economics but unconventional design concepts show the potential for larger incremental improvements in aircraft efficiency. The paper reviews preliminary design system studies of unconventional aircraft including span-distributed loading, multibody, wing-in-ground effect, flatbed and transonic biplane design concepts. The data include a comparison of the performance and economics of each concept to that for conventional designs. All of the design concepts reviewed incorporate appropriate advanced technologies. The aircraft design parameters include Mach numbers from 0.30 to 0.95, design payloads over 1 million pounds, and design ranges up to 5,500 nautical miles. Author

A86-48996#

THE BRITISH AEROSPACE EXPERIMENTAL AIRCRAFT PROGRAMME AND THE ROLE OF SYSTEM DEVELOPMENT COCKPITS

P. V. WHITESIDE (British Aerospace, PLC, Military Aircraft Div., Preston, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 201-212.

The objectives of the Experimental Aircraft Program (EAP) are discussed. The computer software and test facilities utilized to design, develop, and test the systems of the aircraft are described. The aerodynamic and material considerations for the development of a new generation of fighter aircraft are studied. The application of new technologies to the design and production of flight control systems, avionics, and utilities services management systems is examined. A description of the EAP cockpit design and development, which incorporated the new systems developed during the program, is provided. I.F.

A86-48998#

LIGHTER-THAN-AIR AIRCRAFT AS CONTROL CONFIGURED VEHICLE

M. ONDA (Agency of Industrial Science and Technology, Mechanical Engineering Laboratory, Sakura, Japan) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 221-226.

A novel type of LTA aircraft, which is designed as a control configured vehicle and has a collision resistant and a noise abatement axisymmetric hull with a passive boundary-layer control, is proposed. The hull is also made to be a control configured structure to adapt varied load circumstances. The experimental model has a duct in the center axis of a boyant gas-holding envelope, and a small conventional thruster is installed inside the duct. Two sets of control surfaces are located to the front and rear openings of the duct, and under an appropriate control law the vehicle actively holds its stability and enhanced maneuverability performances. This paper deals with the structural design concept of the model and attitude control mechanism as well as its experimental results. Author

A86-49010#

OPTIMUM-OPTIMORUM INTEGRATED WING-FUSELAGE CONFIGURATION FOR SUPERSONIC TRANSPORT AIRCRAFT OF SECOND GENERATION

A. NASTASE (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 324-334. DFG-supported research. refs

An original, hybrid, analytical-numerical method for the design of the optimum-optimorum shape of the integrated wing fuselage configuration, for which all its geometrical characteristics (i.e. cambers, twists, thicknesses and also the plan projections of the wing and of the fuselage) are simultaneously determined in order to obtain a minimum drag, at cruising Mach number, is presented. The design of the optimum-optimorum shape of the integrated wing-fuselage configuration needs 5 seconds computer time, on Cyber 175. Author

A86-49022#

PRECISE SOLUTION FOR RATIONAL TRANSFER PARAMETERS OF FLIGHT VEHICLES

Y. ZENG (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 403-408. refs

The deviations of some design parameters always exist in adjusting the aerodynamic configuration, arrangement and control loop. In this paper, a mathematical model, which is used for calculating precisely transfer parameters of vehicles, is established

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

in the matrix form involving dynamic factors, transform factors, structure parameters and their deviations. It not only simplifies computer aided design programming, but also offers an intuitive sense. Taking the dynamic factors for the function of aerodynamic and flight parameters and their deviations, the calculation method presented here is simplified. Since the transform factors are used, this method is suitable to normal, canard, control wing and ballistic vehicles. Author

A86-49055#

FAILURE ANALYSIS OF AIRCRAFT WINDSHIELDS SUBJECTED TO BIRD IMPACT

A. SAMUELSON and L. SORNAS (3K Akustikbyran AB, Stockholm, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 724-729. refs

Aircraft flying at high speed at low level altitudes run a high risk of bird collision and a number of aircraft accidents each year may be attributed to bird impact. In particular, windshield failure is of concern since it invariably involves pilot injuries. A comprehensive investigation was, therefore, carried out by the Swedish Air Force in order to define the operational envelopes of its aircraft with respect to bird impact. The dynamic behavior of a windshield was studied by means of both linear and nonlinear theories and the results were verified by comparison with test results at the Saab Scania test range. It was shown that a linear analysis was adequate in most of the cases studied. This fact greatly reduced the cost of mapping the stresses of the windshield as function of impact velocity, bird size, and target point. The report summarizes the theoretical background and the verification of the method of analysis and gives the result obtained for the Saab SK60 Trainer Aircraft. Author

A86-49081#

AEROELASTIC TAILORING FOR FLUTTER CONSTRAINTS

J. SCHWEIGER, O. SENSBURG, and C. PONZI (Messerschmitt-Boeckow-Blohm GmbH, Munich, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 981-987. refs

The major findings of a theoretical study by Ponzi (1985) of aeroelastic tailoring for flutter constraints are summarized in this paper. The aerodynamic surface was modelled as a trapezoidal plate consisting of an upper and lower part with up to three different layer orientations. The geometry of the model is described, and the mass distribution is shown along with aerodynamic models and static load cases. The use of the TSO program to calculate the proper load distribution of a steady aeroelastic equilibrium condition and to analyze the strength design is discussed. Various thickness distributions and various deformations for static load cases are shown. The results of dynamic analysis and optimization are discussed for variations of spigot geometry, types of attachment, and balancing masses. The influence of spigot axis sweep angle on flutter speed is shown along with results of flutter calculation for strength design, eigenmodes for increased pitch stiffness, layer distributions for increased flutter speed, and designs with free fiber angles. C.D.

A86-49093#

POTENTIAL APPLICATION OF ADVANCED PROPULSION SYSTEMS TO CIVIL AIRCRAFT

A. BLYTHE (British Aerospace, PLC, Civil Aircraft Div., Hatfield, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1111-1118.

Powerplant options for the 1990's are identified and related to Airliner categories. The influence of safety, efficiency, economy, and noise is considered in terms of obtaining the most suitable powerplant for a given application. The Advanced Feederliner/Regional Airliner is used to assess the influence of open rotors on aircraft efficiency and economics. It is concluded that counterrotating open rotors provide the most efficient known means of propulsion for aircraft cruising at Mach numbers between

0.6 and 0.8. An Advanced Feederliner can show a block fuel advantage of 27 percent, and a range increase of 45 percent by replacing turbofan engines with counterrotating open rotor powerplants. It is noted, however, that an initial DOC advantage of a 20 percent reduction in fuel usage can be cancelled out by a 10 percent increase in aircraft price or a 40 percent increase in powerplant price; therefore, efficiency must be weighed against cost. K.K.

A86-49095#

A GENERAL FORMULATION FOR THE AEROELASTIC DIVERGENCE OF COMPOSITE SWEEPED FORWARD WING STRUCTURES

L. LIBRESCU (Virginia Polytechnic Institute and State University, Blacksburg) and J. SIMOVICH (Israel Aircraft Industries, Ltd., Structural Div., Lod, Israel) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1129-1140. refs

This paper is devoted to the formulation of a simple algorithm allowing the determination, in a closed form, of the divergence instability of advanced composite swept (back and forward) wing structures. The warping restraint effect is incorporated into the analysis and its influence on the associated static instability condition is put into evidence. In this sense, it is shown that in contrast to the case of conventional metallic wings, when the warping restraint effect has a stabilizing influence only, in the case of anisotropic composite wing structures, its influence becomes more complex. The behavior in divergence of swept composite type wings in which framework the warping restraint effect is taken into consideration constitutes the principal goal of this study. The numerical examples illustrate the complex role played by the warping restraint effect on the divergence instability of composite wings. Author

A86-49097#

AEROELASTIC TAILORING OF AFT-SWEEP HIGH ASPECT RATIO COMPOSITE WINGS

J. A. GREEN (Stanford University, CA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1151-1161. refs

The effects of several geometric and aerodynamic parameters on the aeroelastic stability of aft-swept high aspect ratio composite wings are studied. The solution procedure is based on an integrating matrix method, which is a relatively fast numerical procedure. The method does require the wing to be discretized, though not to the same extent as in a finite element formulation, and this allows arbitrary geometries to be investigated. Results are presented to demonstrate some of the effects of wing geometry, and the potential of nonsymmetric composite laminates is evaluated. It is shown that there need not be a severe aeroelastic penalty for using such general laminates. Author

A86-49100#

CONTROL OF INTERIOR NOISE IN ADVANCED TURBOPROPPELLER AIRCRAFT

A. CARBONE, A. PAONESSA (Aeritalia S.p.A., Naples, Italy), L. LECCE, and F. MARULO (Napoli, Università, Naples, Italy) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1171-1185. refs

The importance of limiting interior noise of a new generation turboprop commuter aircraft, the Aeritalia/Aerospatiale ATR-42, has required a continuing effort, started during the preliminary design phase and presently under way with the aircraft in its initial production. The analytical and experimental tools developed during the program execution are described. The related results, with some comparison between theoretical and experimental findings, obtained before flight testing, are briefly discussed. Some comparison of preliminary data from acoustical flight tests, with findings from experimental results obtained in the full-scale fuselage section model, are also presented. Studies presently under way

to define means for further reduction of noise in the fuselage of the new ATR-72 program, are described and current developments of theoretical models capable of predicting the acoustical performance of a fuselage are discussed. Author

A86-49101#

ACTIVE NOISE CONTROL

C. F. ROSS (Topexpress, Ltd., Cambridge, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1186-1189. Research supported by British Aerospace, PLC.

Preliminary experiments were carried out in a conventional propeller aircraft (BAe 748) to demonstrate the advantages of active noise control. It is shown that the internal cabin noise can be attenuated by 15 decibels in the loudest part of the cabin (i.e., around the propeller plane). It is concluded that active control systems will remove the internal noise limitations on the use of prop fans. K.K.

A86-49110#

UTILIZATION OF COMPUTATION AND EXPERIMENT FOR AIRFRAME PROPULSION INTEGRATION DEVELOPMENT

D. L. BOWERS and C. H. BERDAHL (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1295-1304. refs

Computational and experimental engineers must combine efforts to assure efficient use of both computational and experimental resources during future aircraft development. The objective of this cooperative approach is to develop the best possible integration of the propulsion system into the airframe and thereby reduce the enormous risk of committing limited resources to build an unproven design. While a few excellent examples of the joint application of computation and experiment to propulsion integration can be found, a conscious directed effort will be required to satisfy future design problems. The experiment must be used to assist the computational development and the computation must be used to assist experimental accuracy and efficiency. Other factors which currently block cooperative progress such as a lack of code user friendliness and weak management commitment to computations must also be removed. Both the computationalist and the experimentalist should seek to understand the physics of the propulsion component flowfields. Credible progress toward designing optimum propulsion system integrations with the most efficient use of resources will only be achieved through cooperative efforts between both disciplines. Author

A86-49115#

FATIGUE FRACTURE IN LANDING GEAR STEELS

R. J. H. WANHILL (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1347-1355. Research supported by the Royal Netherlands Air Force. refs

Characteristics of fatigue and overload fracture in high strength steel landing gear forgings were investigated. Fatigue fracture was typified by microseerrated acicular ridges (misars) and to a lesser extent by fatigue striations. Overload fracture was by microvoid coalescence (dimples). After severe corrosion due to outdoor exposure it was still possible to identify fatigue fracture, but overload dimples were much less evident. Constant amplitude fatigue crack growth data were used to predict crack growth under block programme flight-by-flight loading. The predictions were made using a characteristic-K approach and were compared with test data. The results were encouraging for analytical estimation of service failure crack growth lives. Author

A86-49117#

NEW DESIGN PROCEDURES APPLIED TO LANDING GEAR DEVELOPMENT

J. VEAUX (Messier-Hispano-Bugatti, Montrouge, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1361-1371.

An account is given of the ways in which the complex and often contradictory objectives of high performance aircraft landing gear design can be approached by the use of CAD. Attention is given to the illustrative case of the tricycle landing gear of the Rafale fighter. The methodology presented encompasses geometrical definition, load and performance values' contribution to the optimization process, stress analysis, and operational safety and reliability considerations. Future development trends for these methods are projected. O.C.

A86-49118#

SHIMMY PROBLEMS OF LANDING GEARS CAUSED BY ELASTIC DEFORMATION OF TIRES

E. SPERLING (Muenchen, Technische Universitaet, Munich, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1372-1382. refs

A systematic comparative study is conducted for extant theories of self-excited landing gear vibrational phenomena, with a view to the theories' physical clarity, computational cost, and precision of reference to the phenomena in question. The performance of the theories upon application to simple sample problems is evaluated, and comparison results are presented in diagram and table forms. O.C.

A86-49119#

MEASUREMENTS OF LANDING GEAR LOADS OF A COMMUTER AIRLINER

A. I. GUSTAVSSON (Flygtekniska Forsoksanstalten, Stockholm, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1383-1389. refs

An account is given of strain gage measurements of forces acting on the nose and main landing gear components of a commuter aircraft, yielding forces in the longitudinal, transverse, and vertical directions under such maneuvers as takeoff, landing, taxiing, and towing. Unexpectedly high transversal loads are noted in the main landing gear during touchdown; the nose gear is severely strained during taxi run steering as well as when the aircraft is in tow. An additional investigation has been conducted with on-line data acquisition during actual aircraft service, revealing differences in load environment that are due to piloting differences, runway conditions and such weather-related conditions as seasonal variations. Attention is given to the data acquisition system used. O.C.

A86-49120*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TOPICS IN LANDING GEAR DYNAMICS RESEARCH AT NASA LANGLEY

H. G. MCCOMB, JR. and J. A. TANNER (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1390-1397. refs

Four topics in landing gear dynamics are discussed. Three of these topics are subjects of recent research: tilt steering phenomenon, water spray ingestion on flooded runways, and actively controlled landing gear. The fourth topic is a description of a major facility recently enhanced in capability. Author

A86-49121#

TAKE-OFF PREDICTION FOR THE AIRBUS A300-600 AND THE A310 COMPARED WITH FLIGHT TEST RESULTS

B. HAFTMANN, F.-J. DEBBELER, and H. GIELEN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1398-1412. refs

The preflight drag of the A310 and A300-600 airliners during one-engine takeoff conditions is presently predicted by means of a semiempirical method involving wind tunnel model tests and turbine-powered simulator investigations of the inoperative engine's drag during climb. The results thus obtained are then corrected to full scale aircraft data, on the basis of a simple scaling rule that projects the effect of Reynolds number on lift, pitching moment and drag. It is demonstrated that the results of the present model/test and scaling methodologies yield predictions that agree with flight test data to within + or - 1 percent of overall drag.

O.C.

A86-49124#

CONFIGURATION AND TRAJECTORY OF HYPERSONIC TRANSPORT WITH AEROTHERMODYNAMIC CONTROL

Y. AIHARA, H. MINAKUCHI, A. MURAKAMI, N. SUDANI (Tokyo, University, Japan), and S. NOMURA (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1431-1441. refs

Aerodynamics of an HST with a range of 16,000 km has been studied on the assumption that the Mach number at the beginning of horizontal cruising is 7. Orbit analysis has been made through modeling of the relations of air density and sound velocity vs. altitude, and of lift-to-drag ratio and specific impulse vs. Mach number, revealing that the aerodynamic characteristic that is most effective in increasing the payload and shortening the flight time is the lift-to-drag ratio. The results of a wind tunnel test of the HST model at Mach number 7 have shown that the geometry of the model almost satisfies the aerodynamic performance assumed in the present orbit analysis. An experiment for heating of the airstream beneath the afterbody suggests the possibility of improving the lift-to-drag ratio. Applicability of the heat addition to a real HST remains a problem.

Author

A86-49129#

DETAILS OF ANALYSIS OF AIRPLANE STRUCTURE ACOUSTIC LOADING IN FLIGHT TESTING

E. V. ARNAUTOV (Nauchno-Issledovatel'skii Aeroinstitut, Kratovo, USSR) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1475-1481.

Current urgency of flight research into airplane structural component acoustic loading is noted. Outlines of the experimental data acquisition and reduction systems are described. Features of current commonly used autoregression method applications in spectral analysis, rejection and diagnostics are considered. Examples of dynamic strain flight tests of an inlet duct and pressure fluctuations on a passenger airplane flap are given.

Author

A86-49132#

RECENT IN-FLIGHT DATA AND ELECTROMAGNETIC RESPONSE OF AN AIRCRAFT STRUCTURE STRUCK BY LIGHTNING

J. L. BOULAY (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1497-1505. DRET-supported research. refs

Recently acquired, accurate measurements of lightning currents, electromagnetic fields on aircraft structure surfaces and, in addition, fields within aircraft structure-defined volumes, have yielded data on such lightning strike features as the pulse waveforms and very fast rise times of the signals. These data confirm the possibility of

high induction coupling with electrical wiring and equipment. The physical mechanisms involved in lightning attachment to aircraft are discussed.

O.C.

A86-49137

SELECTION OF FATIGUE S-N CURVES WITHIN THE FRAMEWORK OF NEW AIRCRAFT DEVELOPMENT [VOLBA UNAVOVYCH S-N KRIVEK V RAMCI VYVOJE NOVEHO LETOUNU]

V. KAHANEK Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1986, p. 7-12. In Czech. refs

The paper describes the basic procedure being applied to the life analysis of a new aircraft developed without laboratory fatigue tests. The structure is divided into individual critical points to which a suitable S-N curve and reliability coefficient are assigned, according to the notch characteristic and the type of structure. For this purpose, the paper gives the design of the S-N curves, including the equations suitable for computer processing by a computer, for structures made of light alloys and steels.

Author

A86-49138

SAFE SERVICE LIFE SCATTERING COEFFICIENT J SUB N (AND/OR ETA SUB 4) AND THE S-N CURVE [ROZPTYLOVY SOUCINITEL BEZPECNE ZIVOTNOSTI J SUB N /RESP. ETA SUB 4/ A S-N KRIVKA]

V. NEJEDLY Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1986, p. 13-27. In Czech. refs

The paper discusses the structure of the scattering coefficients j sub N (and/or eta sub 4 in NLGS-2 requirements) of several aircraft airworthiness requirements. It is demonstrated that the suggestion of Malik (1976) and Nejedly (1975) that these scattering coefficients can be determined from the equation of a unilateral lower tolerance limit in the case of an unknown eta and sigma-squared is true; this approach has been applied to the formulation of j sub N (eta sub 4). The data obtained have been applied to the construction of a program for the fatigue testing of aircraft structures at several load levels.

B.J.

A86-49288

PREDICTION OF THE LIFE OF STRESSED STRUCTURES - A COMPREHENSIVE STUDY OF THE AIRCRAFT LANDING GEAR [PROGNOZIROVANIE DOLGOVECHNOSTI NAPRIAZHENNYKH KONSTRUKTSII KOMPLEKSNOE ISSLEDOVANIE SHASSI SAMOLETA]

B. V. BOITSOV Moscow, Izdatel'stvo Mashinostroenie, 1985, 232 p. In Russian. refs

A method is presented for the comprehensive statistical evaluation of the reliability and service life of the aircraft landing gear. In particular, attention is given to the evaluation of the endurance of landing gear components with allowance for the statistical characteristics of the similarity of fatigue fracture, with the onset of fatigue crack growth used as the criterion. The discussion also covers the effect of structural and manufacturing process related factors on the fatigue strength of landing gear; characteristics of fatigue crack propagation in relation to life estimates, and an analysis and classification of landing gear failures.

V.L.

A86-49444#

SOLID-BEAM MODEL OF A DEFORMABLE AIRCRAFT FOR NATURAL-VIBRATION STUDIES [BRYLOWO-BELKOWY MODEL ODKSZTALCALNEGO SAMOLOTU DO BADANIA DRGAN WLASNYCH]

J. BLASZCZYK (Wojskowa Akademia Techniczna, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Feb. 1986, p. 4-7. In Polish. refs

A dynamic model for approximating a branched system is considered. One-dimensional discretization of the deformable structure assemblies is carried out using the finite element method and a method of multistage structure synthesis. Equation of dynamic equilibrium for the deformable assemblies and rigid components of the fuselage are derived, and conjugation conditions

for the equations are given. The frequency equation and a formula for the natural-vibration mode are also obtained. B.J.

A86-49478

LONG ENDURANCE AIRCRAFT PERFORMANCE

P. MACCREADY (AeroVironment, Inc., Monrovia, CA) Unmanned Systems, vol. 4, Summer 1985, p. 31-33.

A comprehensive evaluation is made of the factors governing the design and achievable performance of ultralight long-endurance, unmanned aircraft for various vehicle sizes and mission profiles. The calculations and tabulations presented are based on a particular vehicle configuration tailored to long duration missions, whose glide ratio at the selected design speed is 27.6. Fossil fuel combustion is used by the powerplant, together with a variable-pitch propeller. It is noted that, for the case of a 100-lb payload, the vehicle would resemble a light, slightly enlarged sailplane; operations at 90,000 ft stress the importance of powerplant design, and call for exceptionally low wing loading. O.C.

A86-49509#

MODERN DEVELOPMENTS IN ROTORCRAFT TECHNOLOGY [MODERNE ENTWICKLUNGEN IN DER DREHFLUEGLER-TECHNOLOGIE]

V. VON TEIN (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985, Paper. 23 p. In German. (MBB-UD-458-85-OE)

The basic characteristics of rotorcraft are briefly examined, taking into account the advantages and the limitations of the helicopter, improvements obtained by replacing rotor blades of metal by designs consisting of plastic materials, and efforts to overcome the limitations of the helicopter on the basis of the development of new vertical takeoff and landing (VTOL) concepts. A description of the technological basis in Germany is presented. Objectives of a West German aerospace company are related to rotors without hinges and without maintenance requirements. Other aims include very long rotor lifetimes, the reduction of cabin vibrations and rotor noise, and an enhancement of the load-carrying capacity. Attention is given to improvements related to rotor aerodynamics, vibration isolation, mechanical propulsion, cellular design methods, rotor and flight control, avionics/cockpit, a flying avionics laboratory, the manned simulator, technological trends concerning engines, and a joint German-French program. G.R.

A86-49638

DEVELOPMENTS IN HELICOPTER GROUND VIBRATION TESTING

J. A. FABUNMI (Maryland, University, College Park) (International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 1986) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, July 1986, p. 54-59. refs

After reviewing existing techniques for helicopter mobility testing, this paper presents some recent formulations and techniques for efficient measurement of structural dynamic characteristics of the helicopter during ground vibration testing. For single point shaking, a new method for calculating the transfer mobility between excitation and response coordinates results in substantial saving in test duration, while assuring acceptable accuracy. Test results using this method are presented and compared with existing methods. The formulation for extending the method to multiple shaker testing is also presented. Author

A86-49808*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

NOISE CONTROL CHARACTERISTICS OF SYNCHROPHASING. II - EXPERIMENTAL INVESTIGATION

J. D. JONES and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1271-1276. Previously cited in issue 01, p. 4, Accession no. A85-10899. refs (Contract NAG1-390)

A86-50111

THE DEVELOPMENT OF AEROELASTIC TAILORING IN THE UNITED STATES

T. J. HERTZ (USAF, Systems Command, Andrews AFB, DC), M. H. SHIRK (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and T. A. WEISSHAAR (Purdue University, West Lafayette, IN) IN: International Symposium on Composite Materials and Structures, Beijing, People's Republic of China, June 10-13, 1986, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1986, p. 220-227. refs

A development history is presented for aeroelastic tailoring of wing structures, which involves the achievement of performance objectives through the creation of external aerodynamic loads by means of controlled deformation, in the context of U.S. industry. The most recent spurt in the development of aeroelastically tailored structures has as its basis the availability of anisotropically fiber-reinforced composite materials and mathematical programming methods. The two most widely used numerical methods in aeroelastic tailoring are the Wing Aeroelastic Synthesis Procedure and the Flutter and Strength Optimization Procedure. Attention is given to the application of these materials and design techniques in the X-29 and HiMAT experimental vehicles. O.C.

A86-50253#

BK 117 FLIGHT TESTS FOR CERTIFICATION OF AN EXPANDED FLIGHT ENVELOPE

A. TELEKI (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p. (MBB-UD-452-85-OE)

Initial certification of the BK 117 was to a gross weight of 2850 kg (6284 lb) as originally planned. However, in response to customer demand, it was a logical step to certificate the helicopter to the highest gross weight it was capable of without major modification. Thus an initial exploratory flight test phase to explore and define the limitations of the flight envelope was followed by a certification programme to furnish data and proof of compliance with the relevant regulations. These tests were not confined to a temperature range of atmospheric conditions, in addition low ambient temperature tests in the Northwest Territories of Canada up to the polar-circle with temperatures of -41 C and high temperature tests in Khartoum, Sudan, Africa, and temperatures up to +46 C were incorporated. During the test phases involving low speed controllability and for flight path measurements for Cat A and B operation some novel measuring techniques were employed, partly in parallel with conventional means in order to prove and define the limitations of these new methods. A considerable saving in flight test time required was obtained in certain cases by using these means. Author

A86-50255#

DEVELOPMENT OF THE BO 105 LS

A. HORLEBEIN and G. POLZ (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) CASI, Annual Meeting, Montreal, Canada, May 27, 28, 1985, Paper. 13 p. (MBB-UD-456-85-OE)

The BO 105 LS is the newest version of the BO 105-family. It is specifically designed for operation at high altitudes and extreme temperature conditions as well as for improved single engine performance. The presentation summarizes the technical main features and milestones of the BO 105 LS program. Performance and flight characteristics in the extreme regions of the extended flight envelope are discussed. The developmental flight test phase and the results of the numerous certification test campaigns are presented. The growth potential and versatile improvements of BO 105 LS due to the application of modern technology are discussed. Author

A86-50256#

STRUCTURAL DESIGN AND ANALYSIS ASPECTS OF COMPOSITE HELICOPTER COMPONENTS

W. BUCHS and H. BANSEMER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 29 p. refs (MBB-UD-454-85-OE)

Structural design and analysis aspects of composite helicopter components in various areas of application are presented. The structures under discussion include main and tail rotors, drive shafts, control elements, and the airframe primary and secondary structures. Two concepts for main rotors: an all-composite rotor without lubricated bearings and a rotor with elastomeric bearings, are explained, and the structure of a composite bearingless tail rotor flown on the BK 117 helicopter is described. An airframe primary structure made of aramid-fiber and carbon-fiber composites, which consists of only seven major units, is presently under development for the BK 117 helicopter. I.S.

A86-50347#

AIRCRAFT PROTECTION AGAINST LIGHTNING STRIKES [SCHUTZ VON FLUGZEUGEN BEI BLITZEINSCHLAGEN]

W. BOETTICHER (Hannover, Universitaet, Hanover, West Germany) UNI Hannover (ISSN 0171-2268), vol. 12, no. 2, 1985, p. 3-9. In German. refs

Procedures for testing the reliability of lightning strike protection in aircraft are examined. A cost-benefit analysis of such protection is briefly discussed, and the physical phenomena that occur when lightning strikes a commercial aircraft are reviewed. It is shown how research using simple materials has recently made a decisive contribution to the development of these protective technologies. C.D.

N86-31562*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IN-FLIGHT PHOTOGRAMMETRIC MEASUREMENT OF WING ICE ACCRETIONS

R. C. MCKNIGHT, R. L. PALKO (Calspan Field Services, Inc., Arnold AFS, Tenn.), and R. L. HUMES 1986 14 p Presented at the 24th Aerospace Sciences Meeting, Reno, Nev., 6-8 Jan. 1986; sponsored by AIAA (NASA-TM-87191; E-2847; NAS 1.15:87191) Avail: NTIS HC A02/MF A01 CSCL 01C

A photographic instrumentation system was developed for the Lewis icing research aircraft to measure wind ice accretions during flight. The system generates stereo photographs of the accretions which are then photogrammetrically measured by the Air Force Arnold Engineering and Development Center. The measurements yield a survey of spatial coordinates of an accretion's surface to an accuracy of at least + or - 0.08 cm. The accretions can then be matched to corresponding icing cloud and aerodynamic measurements. The system is being used to measure rime, mixed, and clear natural ice accretions. Author

N86-31563*# National Aeronautics and Space Administration, Washington, D.C.

MISSION ADAPTIVE WING SOARS AT NASA FACILITY

D. RAHN and L. REINERTSON (National Aeronautics and Space Administration, Dryden (Hugh L.) Flight Research Center, Edwards, Calif.) 29 Aug. 1986 2 p (P86-10182) Avail: NTIS HC A02/MF A01 CSCL 01C

Research pilots have flown the Mission Adaptive Wing (MAW) aircraft, a highly modified F-111 jet fighter, from subsonic speeds up to Mach 1.4 in initial flight tests. The initial test flights are clearing the envelope with the wings flexed at various curvatures. This process allows further research data to be safely gathered so that designers of future variable camber wing aircraft have the best information possible. The altitude envelope was cleared from 27,500 down to 7,500 feet where denser air can cause more stress on the aircraft. Testing with the aircraft was conducted with wing sweep angles of 26 and 58 degrees. At the conclusion of the performance tests in the manual configuration, the system will be reconfigured for automatic mode tests. The limited automatic

modes include maneuver camber control where the wings are deflected automatically to the best lift versus drag combination for a particular speed; cruise camber control which can help protect the aircraft from high G stresses; and maneuver enhancement/gust alleviation which is designed to improve the aircraft's up and down movement response to pilot commands and reduce the aircraft response to turbulence. B.G.

N86-31564# Federal Aviation Administration, Washington, D.C. ADVISORY CIRCULAR: DESIGN CONSIDERATIONS TO PROTECT FUEL SYSTEMS DURING A WHEELS-UP LANDING

24 Jul. 1986 4 p

(FAA-AC/25.994-1) Avail: NTIS HC A02/MF A01

Guidelines and methods for complying with the requirements of the Federal Aviation Regulations (FAR) are presented. These guidelines pertain to protecting fuel system components located in the engine nacelles and the fuselage from damage which could result in spillage of enough fuel to constitute a fire hazard as a consequence of a wheels-up landing on a paved runway. Author

N86-31565# Societe Nationale Industrielle Aerospatiale, Paris (France).

ANEMOBAROMETRY IN FLIGHT CONTROL. A-320 AERODYNAMICS. THE TURBOREACTORS AIR INLET [L'ANEMOBAROMETRIE: ELEMENT ESSENTIEL DE LA CONDUITE DU VOL. AERODYNAMIQUE A-320. ENTREE D'AIR DES TURBOREACTORS]

1985 10 p In FRENCH Presented at the Aeronautique Toulouse 2000, Toulouse, France, Dec. 1985; sponsored by Confederation Francaise de l'Encladrement CGC (SNIAS-861-111-114; ETN-86-97592) Avail: NTIS HC A02/MF A01

The utilization and calibration of barometric altimeters and the design and wind tunnel verification of the aerodynamic characteristics of the A-320 aircraft turbojet engine air intake are discussed. ESA

N86-31567# Societe Nationale Industrielle Aerospatiale, Paris (France).

THE A-320 AERODYNAMICS. THE TURBOREACTOR AIR INLET [AERODYNAMIQUE A-320. ENTREE D'AIR DES TURBOREACTORS]

A. CONDAMINAS In its Anemobarometry in Flight Control. A-320 Aerodynamics. The TurboReactors Air Inlet 6 p 1985 In FRENCH (NOTE-427.021/86) Avail: NTIS HC A02/MF A01

The design of air inlets is discussed and the solution adopted for the A-320 aircraft engines is described. The tests performed in wind tunnel are detailed. The results show that the flow around the nacelle is in agreement with the specifications in the whole range of operational Mach number and incidence angles. ESA

N86-31568*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

FLIGHT TEST OF PASSIVE WING/STORE FLUTTER SUPPRESSION

F. W. CAZIER, JR. and M. W. KEHOE Aug. 1986 27 p Presented at the 1986 Aircraft/Stores Compatibility Symposium, Wright-Patterson AFB, Ohio, 8-10 Apr. 1986 (NASA-TM-87766; NAS 1.15:87766) Avail: NTIS HC A03/MF A01 CSCL 01C

Flight tests were performed on an F-16 airplane carrying on each wing an AIM-9J wingtip missile, a GBU-8 bomb near midspan, and an external fuel tank. Baseline flights with the GBU-8 mounted on a standard pylon established that this configuration is characterized by an antisymmetric limited amplitude flutter oscillation within the operational envelope. The airplane was then flown with GBU-8 mounted on the decoupler pylon. The decoupler pylon is a NASA concept of passive wing-store flutter suppression achieved by providing a low store-eylon pitch frequency. The decoupler pylon successfully suppressed wing-store flutter throughout the flight envelope. A 37 percent increase in flutter

velocity over the standard pylon was demonstrated. Maneuvers with load factors to 4g were performed. Although the static store displacements during maneuvers were not sufficiently large to be of concern, a store pitch alignment system was tested and performed successfully. One GBU-8 was ejected demonstrating that weapon separation from the decoupler pylon is normal.

Author

N86-31569# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

THE APPLICATION OF ENERGY TECHNIQUES TO PROPELLER-DRIVEN AIRPLANES M.S. Thesis

D. B. YOUNGBLOOD Dec. 1985 92 p
(AD-A167113; AFIT/CI/NR-86-53T) Avail: NTIS HC A05/MF A01 CSCL 01B

This thesis examines the validity of using the energy technique on propeller-driven aircraft during a climb analysis. It compares an accepted subsonic aircraft climb analysis method (pure potential energy increase) with an acceleration analysis procedure (pure kinetic energy increase) that has been a subject of criticism when used within a subsonic flight test program because of aircraft power limitations and flight test assumptions. The energy-state approximation was applied to a subsonic, propeller-driven aircraft using both a sawtooth climb analysis procedure and level acceleration method. Results showed that energy techniques, i.e., correlation between sawtooth and level acceleration methods, are a valuable support tool to the previously isolated potential energy (sawtooth climb) method. Data demonstrated a test time savings of approximately 7:1 with a variance in overall correlation that, although not within acceptable standards, is believed to be reducible with a more dedicated instrumentation selection. Data correlation suggested good agreement on best rate-of-climb speed determination. However, this should be an asset in reducing the time previously required for determination of excess thrust horsepower. Further testing, specifically with the level acceleration method, using higher resolution data acquisition equipment (with possibly an accelerometer) would fully demonstrate the extent of unaccountable losses and resulting disagreement between the two methods.

GRA

N86-31570# Boeing Military Airplane Development, Seattle, Wash.

VULNERABILITY METHODOLOGY AND PROTECTIVE MEASURES FOR AIRCRAFT FIRE AND EXPLOSION HAZARDS. VOLUME 2: AIRCRAFT ENGINE NACELLE FIRE TEST PROGRAMS. PART 1: FIRE DETECTION, FIRE EXTINGUISHMENT AND SURFACE IGNITION STUDIES Final Report, Feb. 1981 - Oct. 1984

A. M. JOHNSON and A. F. GRENICH Jan. 1986 279 p
(Contract F33615-78-C-2063)
(AD-A167356; D180-28861-1; AFWAL-TR-85-2060-VOL-2-PT-1)
Avail: NTIS HC A13/MF A01 CSCL 01C

Fire tests and extinguishant concentration tests were conducted using a simulated portion of the F-16 aircraft engine compartment in the Aircraft Engine Nacelle (AEN) fire test simulator at WPAFB. Combat damage simulation included outer compartment wall penetration allowing either inflow or outflow of ventilation airflow through and external wound and fan perforation or engine bleed air line damage. Standard fire and agent concentration test techniques were developed. Existing specifications were found to be adequate in terms of quantity of fire extinguishing agent. Results also indicated that more rapid agent release resulted in more effective use of the agent. Halon 1301 performed significantly better than Halon 1202, contrary to what the available literature indicated. Fires with combat damage inflow simulation added were the most difficult to extinguish because hot surface ignition sources were created soon after the test fire was ignited. For these, the quantity of agent specified would have been adequate only if the agent reached the fire within a few seconds after ignition.

GRA

N86-31571# Boeing Military Airplane Development, Seattle, Wash.

VULNERABILITY METHODOLOGY AND PROTECTIVE MEASURES FOR AIRCRAFT FIRE AND EXPLOSION HAZARDS. VOLUME 1: EXECUTIVE SUMMARY Final Report, Feb. 1981 - Oct. 1984

A. F. GRENICH Jan. 1986 40 p
(Contract F33615-78-C-2063)
(AD-A167443; D180-28860-1-VOL-1; AFWAL-TR-85-2060-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 13L

This report summarizes the research conducted by the contractor on airplane engine compartment and fuel tank fire safety research. The value of ground testing, using the Aircraft Engine Nacelle (AEN) and the Simulated Aircraft Fuel Tank Environment (SAFTE) facilities, was clearly evident as the testing proceeded. Extinguishant tests of simulated nacelle fires indicated that current criteria for extinguishant concentration and duration were more than adequate for intact nacelles inert gas generator systems (OBIGGS) revealed that both the permeable membrane and molecular sieve adequately inerted the test fuel tank. However, some minor operational difficulties were experienced with both test units which would have to be corrected prior to producing flight hardware.

GRA

N86-31572# Boeing Military Airplane Development, Seattle, Wash.

VULNERABILITY METHODOLOGY AND PROTECTIVE MEASURES FOR AIRCRAFT FIRE AND EXPLOSION HAZARDS. VOLUME 2: AIRCRAFT ENGINE NACELLE FIRE TEST PROGRAMS. PART 2: SMALL SCALE TESTING OF DRY CHEMICAL FIRE EXTINGUISHANTS Final Report, Feb. 1981 - Oct. 1984

L. A. DESMARIS Jan. 1986 279 p
(Contract F33615-78-C-2063)
(AD-A167444; D180-28862-VOL-2-PT-2;
AFWAL-TR-85-2060-VOL-2-PT-2) Avail: NTIS HC A13/MF A01 CSCL 01B

Dry chemical fire extinguishing agents were studied in a simulated small scale aircraft engine nacelle environment to observe the ability of these agents to prevent re-ignition, a known deficiency of the presently used gaseous agents. An injector was developed which effectively dispersed agent into the airstream; a fuel spray behind a flameholder, ignited and sustained by a hot surface, was used as the test scenario. The agents were found to be effective in very small quantities (less than 30 grams) for initial suppression of the fire, but permanent extinguishment was found to be a function of test conditions. The agents tended to accumulate on test surfaces and cause some corrosion as the result of repeated applications but were easily cleaned from affected surfaces.

GRA

N86-31573# Boeing Military Airplane Development, Seattle, Wash.

VULNERABILITY METHODOLOGY AND PROTECTIVE MEASURES FOR AIRCRAFT FIRE AND EXPLOSION HAZARDS. VOLUME 3: ON-BOARD INERT GAS GENERATOR SYSTEM (OBIGGS) STUDIES. PART 2: FUEL SCRUBBING AND OXYGEN EVOLUTION TESTS Final Report, Feb. 1981 - Oct. 1984

P. M. MCCONNELL, G. A. DALAN, and C. L. ANDERSON Jan. 1986 84 p
(Contract F33615-78-C-2063)
(AD-A167445; AFWAL-TR-85-2060-VOL-3-PT-2) Avail: NTIS HC A05/MF A01 CSCL 01B

A basic consideration in designing an on-board inert gas generator system (OBIGGS) is to manage the evolution of dissolved oxygen in the fuel such that an inert ullage is maintained. Fuel scrubbing, in which an inert gas is bubbled through the fuel, is the common method of removing dissolved oxygen. Analytical modeling of the scrub gas requirements for fuel scrubbing required experimental data for validation. Tests were conducted to determine if a model based on the ideal gas law, published solubility coefficients, and partial pressure relationships was valid. The

excellent agreement between calculated results and test data verified that such a model is valid. GRA

N86-31574# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.

AERIAL REFUELING EVALUATION OF THE CH-47D HELICOPTER Final Report, 6-9 Aug. 1985

R. D. ROBBINS, P. J. SULLIVAN, and M. K. HERBST Aug. 1985 56 p

(AD-A167575) Avail: NTIS HC A04/MF A01 CSCL 01C

A feasibility evaluation of aerial refueling the Boeing Vertol CH-47D helicopter (USA S/N 84-24159) equipped with a Boeing Vertol designed prototype aerial refueling system was conducted by the US Army Aviation Engineering Flight Activity (USAAEFA). Aerial refueling operations were performed with an HC-130P tanker aircraft and included a tanker turbulence evaluation, handling qualities while performing refueling procedures, and prototype aerial refueling system operations. Twenty-five refueling probe to drogue engagements were performed. During one engagement, 5070 pounds of fuel were transferred from the tanker to the CH-47D. Six shortcomings, all of which were related to the aerial refueling system, were identified for correction in the production design. The most significant of these was the increased maintenance requirements imposed by the use of refueling probe restraint cables. Within the limited scope of this evaluation aerial refueling of the CH-47D helicopter is a feasible concept. GRA

N86-31575# Naval Postgraduate School, Monterey, Calif.

A TRADE-OFF STUDY OF TILT ROTOR AIRCRAFT VERSUS HELICOPTERS USING VASCOMP 2 AND HESCOMP M.S. Thesis

T. P. WALSH Mar. 1986 218 p

(AD-A167719) Avail: NTIS HC A10/MF A01 CSCL 01C

Trade-off studies were conducted wherein two versions of tilt rotor aircraft were examined to determine optimum mission distances where the tilt rotor designs were superior to a comparable contemporary (pure) helicopter. Two FORTRAN computer programs (VASCOMP 2 and HESCOMP) were used to predict aircraft performance. Program results were validated using data from independent sources. A simplified user's manual is included (with sample data and program output) for VASCOMP 2. The experimental results substantiate that the V-22, designated to replace the CH-46F among other aircraft, will offer significant improvements in speed, loiter endurance, hover endurance, performance, and efficiency. The results lend further credence to the manufacturer's claims that tilt rotor aircraft can transport more passengers/payload over longer distances in less time than conventional helicopters while retaining the important advantage of vertical takeoff and landing. It is acknowledged that the tilt rotor can readily perform transport missions using less fuel than helicopters but if a large percentage of hovering flight is required, conventional rotary wing aircraft are far more efficient from a fuel consumption standpoint. However, they do not have the staying power that the tilt rotor demonstrates. GRA

N86-31576# Sandia National Labs., Albuquerque, N. Mex.

AIRBORNE INTRUDER DETECTION CONSIDERATIONS

R. P. SYLER Feb. 1986 5 p Presented at the Carnahan Conference on Security, Lexington, Ky., 14 May 1986 (Contract DE-AC04-76DP-00789)

(DE86-006462; SAND-85-2236; CONF-860519-4) Avail: NTIS HC A02/MF A01

This paper addresses the considerations the DOE-OSS is giving to the airborne threat to their sensitive facilities. They are working towards establishing prohibited airspace over these facilities and tasked SNL to study the techniques for monitoring this airspace. The SNL study looked at various technologies that might be employed to monitor designated airspace. The results of the study indicate that certain dedicated radar systems are candidates, but that alternatives to these are needed. SNL is presently working on developing a system utilizing FAA ASR data at the DOE facilities, and on a seismic-acoustic helicopter detector system; these are possible alternatives to dedicated radars. DOE

N86-31577# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Bereich Luftfahrt.

TECHNOLOGY DEMONSTRATION FOR INVESTIGATION OF THE NEW POSSIBILITIES OF AMPHIBIOUS FLYING BOATS, PHASE 2 Final Report, Dec. 1984

G. KRIECHBAUM Bonn, West Germany Bundesministerium fuer Forschung und Technologie Dec. 1985 201 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie

(BMFT-FB-W-85-022; ISSN-0170-1339; ETN-86-97466) Avail: NTIS HC A10/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 36.50

The effects of new technologies on the amphibious flying boat open-sea capability, efficiency, and economical and flexible application were studied during a flight test program. Configuration and manufacture are described and technical characteristics are presented. Tests were performed on land, in water (inland water areas) and at sea to determine the corrosion resistance, the effects of the introduction of fiber composite materials in wings, and the all-weather landing procedures for amphibious aircraft. The craft can be used in open sea and does not require a maintenance and overhaul infrastructure, and shows good resistance to corrosion in salty water. The development of shock-absorbing fiber composite material structures is recommended. ESA

N86-31578# European Space Agency, Paris (France).

INVESTIGATIONS IN LANDING PROCESS OF AIRCRAFT BY MEANS OF THE MONTE-CARLO METHOD

H. J. PETERS Dec. 1985 109 p Original language document was announced as N86-14269

(ESA-TT-951; DFVLR-FB-85-27; ETN-86-97583) Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne, West Germany DM 35.50

A landing approach simulation model based on the data from a civil airport and on the Monte Carlo theory is developed using the General Purpose Simulation System on FORTRAN 4. The model is improved to investigate the landing process with constant and variable landing times. The theoretical landing time distribution with waiting times verified with the Chi-square test show good agreement with the empirical landing time distribution. The turn time and landing time distribution with waiting time parameters are verified by statistical comparison of the simulated distribution and the empirical one. The efficiency of the test distributions is improved with a relevant landing time delimitation. The test distributions are tested successfully in other airports. ESA

N86-31579# European Space Agency, Paris (France).

USER'S MANUAL FOR THE FALCON SYSTEM

Dec. 1985 110 p Original language document was announced as N86-10721

(ESA-TT-936; DFVLR-MITT-85-08; ETN-86-97800) Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne, West Germany DM 36.50

The user manual for the meteorological research aircraft Falcon E, operated by DFVLR, is presented. The system and its technical data are described. The meteorological mission possibilities are discussed, and measuring campaigns are reviewed. Basic and special equipment is described. The onboard data acquisition system and the operational data evaluation programs are discussed. ESA

N86-32425# Aeronautical Research Labs., Melbourne (Australia).

A MATHEMATICAL MODEL OF THE SEA KING MK.50 HELICOPTER AERODYNAMICS AND KINEMATICS

M. J. WILLIAMS and A. M. ARNEY 1986 63 p

(ARL-AERO-TM-379; AR-004-467) Avail: NTIS HC A04/MF A01

Details are given of the expressions used to describe the aerodynamics and kinematics of the Sea King Mk.50 helicopter during steady flight and low rate maneuvers up to an advance ratio of 0.3. The aerodynamics/kinematics formulation is a major component of the Sea King mathematical model developed by

Aeronautical Research Laboratories (ARL) for flight simulation of this anti-submarine warfare helicopter. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

N86-32428# Naval Postgraduate School, Monterey, Calif.
SURVIVABILITY CONSIDERATIONS DURING AIRCRAFT CONCEPTUAL DESIGN M.S. Thesis

R. J. GILMAN Mar. 1986 100 p
 (AD-A168555) Avail: NTIS HC A05/MF A01 CSCL 01C

Survivability, capability, maintainability, and reliability will establish the effectiveness of a combat aircraft. Considerations for the ilities must take place during the conceptual design phase. Retrofit of survivability enhancement has historically increased weight, drag, and cost, while decreasing capability and performance. Proper application of the six susceptibility reduction concepts and the six vulnerability reduction concepts must take place before the design is established to maximize effectiveness and minimize penalties. In this thesis, the application of survivability enhancement techniques to the conceptual design is presented in general and also specifically applied to the design of a long range Strike Fighter aircraft. General guidelines for susceptibility and vulnerability reduction for any aircraft are also presented.

Author (GRA)

N86-32429# Office National d'Etudes et de Recherches
 Aérospatiales, Paris (France).

DYNAMIC IDENTIFICATION PROCEDURE AND LIFT CERTIFICATION OF LIGHT AIRCRAFT AND GLIDERS Final Report [PROCEDURE D'IDENTIFICATION DYNAMIQUE ET DE CERTIFICATION AU FLOTTEMENT DES AVIONS LEGERS ET PLANEURS]

G. PIAZZOLI Jan. 1986 37 p In FRENCH
 (Contract STPA-83-95-019)
 (ONERA-RT-12/1677-RY-090-R; ETN-86-97641) Avail: NTIS HC A03/MF A01

The problems found in certification testing of light aircraft are examined in order to make choices compatible with time and cost constraints. The description of test procedures includes experimental methods to characterize the modal behavior of the structure in the presence of weak nonlinear effects, mixed methods to compute the dynamic behavior of the flight controls, and numerical methods to determine the aeroelastic coupling and the critical velocities. It is shown that a detailed analysis is required and that the described procedures allow a fast, low cost, and safe characterization. ESA

N86-32430# National Aerospace Lab., Amsterdam (Netherlands).
 Structures and Materials Div.

THE GENERATION OF EQUAL PROBABILITY DESIGN LOAD CONDITIONS, USING POWER SPECTRAL DENSITY (PSD) TECHNIQUES

R. NOBACK 23 Jan. 1986 66 p
 (Contract NIVR-1995)
 (NLR-TR-85014-U; B8665725; ETN-86-98036) Avail: NTIS HC A04/MF A01

A method to generate consistent sets of design load conditions of aircraft design loads determined using the design envelope criterion of the power spectral density (PSD) method is derived. The method is based on the use of the correlation coefficients between the loads. Two sets of design load conditions have special properties and are proposed for practical use. Approximations to the proposed methods are given for the case that the design loads are determined with the Mission Analysis criterion of the PSD method. ESA

A86-47319

IMPLICATIONS ASSOCIATED WITH THE OPERATION OF DIGITAL DATA PROCESSING IN THE PRESENCE OF THE RELATIVELY HARSH EMP ENVIRONMENTS PRODUCED BY LIGHTNING

R. HESS (Sperry Corp., Aerospace and Marine Group, Phoenix, AZ) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 289-292. refs

The relative susceptibility of analog and digital avionics computers to data-flow disruptions or operating errors arising when an aircraft is exposed to lightning EMPs is analyzed. The operation of analog and digital computers is reviewed, and typical EMP effects are discussed. It is concluded that both types of computing equipment are subject to EMP breakdown, and that direct lightning testing of analog equipment may give results more indicative of the in-service lightning resistance of the equipment than can be the case for digital equipment. Some general recommendations regarding design criteria and qualification testing are given, and the potentially negative implications of increased use of CFRP in aircraft construction, lower susceptibility/vulnerability levels in electronic equipment, and larger data-processing requirements are indicated. T.K.

A86-47325

RANGING AND AZIMUTHAL PROBLEMS OF AN AIRBORNE CROSSED LOOP USED AS A SINGLE-STATION LIGHTNING LOCATOR

L. W. PARKER (GTE Government Systems Corp., Westborough, MA) and H. W. KASEMIR (Colorado Scientific Research Corp., Berthoud) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 357-362. refs

(Contract F09603-83-C-1680)

Stormscope and airborne radar data are analyzed to assess the lightning-location capability of a single-station crossed loop system. A novel approach is proposed whereby individual discharges are identified and in effect, radial and azimuthal spreads can be determined. The results show: (1) large radial spreads that severely deteriorate the instrument's ranging capability, (2) reasonably good azimuth capability for distant lightning and (3) deterioration of azimuth capability for nearby lightnings and for all single-stroke flashes. A method (based on a continuous triangulation technique) is suggested as means of processing azimuth data in such a way as to infer range while reducing the effective radial spread. K.K.

A86-47420#

A PARAMETER INSENSITIVE TECHNIQUE FOR AIRCRAFT SENSOR FAULT ANALYSIS USING EIGENSTRUCTURE ASSIGNMENT AND ANALYTICAL REDUNDANCY

R. J. PATTON, S. W. WILLCOX (York, University, England), and S. J. WINTER (Royal Aircraft Establishment, Flight Systems Dept., Bedford, England) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 165-179. Research supported by the Ministry of Defence (Procurement Executive). refs

(AIAA PAPER 86-2029)

A powerful approach to fault diagnosis in aircraft sensors using estimation error in observation space is demonstrated. This new

method constitutes a robust observer fault detection filter in which the effects of plant parameter variations and process disturbances are minimized. The robustness of the method make it possible to place low thresholds for rapid detection of faults, even in unstable loop integrity situations. The observation error subspace used by the method obviates the need to compute the state estimation vector, allowing for easy implementation in real time computer systems. The use of a bank of observers with different measurement pairs permits fault isolation. These advantages are demonstrated with a simulation example. C.D.

A86-47457#

FREQUENCY AND TIME DOMAIN DESIGNS OF A STRAPDOWN VERTICAL DETERMINATION SYSTEM

I. Y. BAR-ITZHACK (Technion - Israel Institute of Technology, Haifa, Israel) and I. ZIV IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 505-515. Research sponsored by Condor Pacific, Ltd. refs

(AIAA PAPER 86-2148)

An attractive alternative to the gyro for determining the direction of the vertical is introduced. The bulky vertical gyro is replaced by a couple of small strapdown inertial sensors and a processing unit. This system is lighter and smaller than the gyro, consumes less power, has larger MTBF, and its maintenance cost is lower. The system is described, and the computation involved in the determination of the vertical is shown. The filter design problem is described and addressed using the frequency domain approach. The time domain design of the system using the extended Kalman filter is described. C.D.

A86-47511*# Charles River Analytics, Inc., Cambridge, Mass. DESIGN CONSIDERATIONS FOR FLIGHT TEST OF A FAULT INFERRING NONLINEAR DETECTION SYSTEM ALGORITHM FOR AVIONICS SENSORS

A. K. CAGLAYAN, P. M. GODIWALA (Charles River Analytics, Inc., Cambridge, MA), and F. R. MORRELL (NASA, Langley Research Center, Hampton, VA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 10 p. refs

(AIAA PAPER 86-2030)

This paper summarizes the modifications made to the design of a fault inferring nonlinear detection system (FINDS) algorithm to accommodate flight computer constraints and the resulting impact on the algorithm performance. An overview of the flight data-driven FINDS algorithm is presented. This is followed by a brief analysis of the effects of modifications to the algorithm on program size and execution speed. Significant improvements in estimation performance for the aircraft states and normal operating sensor biases, which have resulted from improved noise design parameters and a new steady-state wind model, are documented. The aircraft state and sensor bias estimation performances of the algorithm's extended Kalman filter are presented as a function of update frequency of the piecewise constant filter gains. The results of a new detection system strategy and failure detection performance, as a function of an update frequency, are also presented. Author

A86-47780

A MINIMUM APPROACH TO FLIGHT TESTING

R. R. L. RENZ and W. G. SCHWEIKHARD (Kohlman Systems Research, Inc., Lawrence, KS) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 1.4-1 to 1.4-9.

An evaluation is made of current self-contained flight test systems that are based on digital electronics and which further rely on digital processing for analytical results. Attention is given to a state-of-the-art combination of microprocessor and hybrid chip technologies constituting a high quality/medium capability self-contained flight test system which encompasses analytical hardware and software; these analytical system elements employ

dynamic flight test maneuvers to extract stability and control coefficients, thrust and drag coefficients, takeoff/landing characteristics, and ground effects. Plots of corrected engineering data can be generated by these means within hours of a test flight's completion. O.C.

A86-47788

FLIGHT TESTING ON CUSTOMER AIRCRAFT WITH A PORTABLE AIRBORNE DIGITAL DATA SYSTEM

B. BILLINGSLEY (Boeing Commercial Airplane Co., Seattle, WA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 4.1-1 to 4.1-4.

The Portable Airborne Digital Data System (PADDS) has been designed to improve testing efficiency for new aircraft while having minimum impact on their operation. PADDS has been certified in a manner similar to that of other advanced avionics systems, and may be installed in the electronics bay of such aircraft as the B767 for in-service operation. Attention is given to PADDS's LRU architecture, data acquisition and reduction methods, and various applications. O.C.

A86-47790

AVIONICS DIGITAL DATA ACQUISITION SYSTEM

M. W. GIBSON (McDonnell Aircraft Co., Saint Louis, MO) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 4.4-1 to 4.4-6.

A high capacity digital data acquisition system for flight tests of high performance fighter aircraft must be small, yet capable of monitoring many parameters at high data rates in order to reduce the number of flights required in a given test program. Attention is presently given to a system answering these performance criteria, which will be used in F/A-18 flight testing. The system is structured in such a way that the user can assemble a data system architecture uniquely suited to the requirements of the given test, through the arrangement of an array of standard functional modules. O.C.

A86-48531

OPTIMIZATION OF ONBOARD SYSTEMS OF DATA ACQUISITION AND PROCESSING [OPTIMIZATSIIA BORTOVYKH SISTEM SBORA I OBRABOTKI DANNYKH]

V. A. VITTIKH and V. A. TSYBATOV Moscow, Izdatel'stvo Nauka, 1985, 176 p. In Russian. refs

Aspects of the optimization of airborne systems of data acquisition and processing are examined. A model of such systems is presented, and a mathematical formulation of the optimization problem in terms of optimal design theory is given. Particular consideration is given to: (1) the optimization of the time diagram of the acquisition and processing process and (2) topological optimization. A general optimization algorithm based on these two optimization approaches is then proposed. B.J.

A86-49051#

AVIONICS FAULT DATA ACQUISITION - A CONCEPT FOR CIVIL TRANSPORT AIRCRAFT

T. STIER (Airbus Industrie, Blagnac, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 692-696.

The use of the centralized fault display system (CFDS) to improve line/ramp maintenance efficiency is examined. The CFDS provides: fault display on two, multipurpose CRT display units, the monitoring of all systems, an optional, multipurpose printer on the flight deck, easy configuration control, access to equipment bays, a reduction in ramp testing, and automatic printouts of failure events. The centralized result display interface unit, the multipurpose control display units, the datalink, and interrelated avionics and maintenance systems are described. The application of expert systems to maintenance diagnostics is being researched. I.F.

A86-49085#

PERFORMANCE EVALUATION OF A LINEAR RECURSIVE TECHNIQUE FOR AIRCRAFT ALTITUDE PREDICTION IN AIRBORNE COLLISION AVOIDANCE SYSTEMS

A. BADACH and P. FORM (Braunschweig, Technische Universität, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1017-1025.

This paper analyses the performance of a linear recursive technique for the aircraft altitude prediction. This prediction technique has been employed in the collision avoidance system (TCAS II). It is based on altitude reports which are derived from barometric altimeters and are quantized in 100-foot increment. This prediction technique employs the observed level occupancy time, i.e. the time within the aircraft crosses one increment of 100 feet. It is shown that the estimate of the aircraft is biased. The bias value is evaluated in dependence on the aircraft velocity, the update time and the velocity estimation time. Formulas for the probability density function of the velocity estimator is given. The use of this probability distribution for the aircraft altitude prediction is presented.

Author

A86-49131#

THE DEVELOPMENT OF A FIBRE OPTIC DATA BUS FOR HELICOPTERS

M. J. KENNETT (Westland Helicopters, Ltd., Yeovil, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1490-1496. Research supported by the Royal Aircraft Establishment.

Attention is given to the results of a 30-month development program concerned with the design of a fiber-optic data bus for helicopter applications which would be compatible with Britain's MIL-STD-1553B data transmission standard. The primary problem encountered was with the substantial amount of optical power lost at couplers and connector interfaces. The design tradeoffs encompassed system optical power budgets, interconnect harness layout options, and optical transmitter and receiver requirements. The system architecture developed has a full, 31-terminal interconnect capability, employing a totally passive bus with no signal regeneration. Future avionics applications of optical data transmission are projected.

O.C.

A86-49142

STRAIN-GAUGE AUTOPILOT ALTITUDE CORRECTOR [TENZOMETRICKY KOREKTOR VYSKY AUTOPILOTA]

J. SMETANA Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1986, p. 101-106. In Czech.

Described are the construction and function of an altitude corrector which operates in the autopilot system as a sensor of barometric height. The device is equipped with bonded semiconductor strain gauges produced in the CSSR. Presented are some calculations relating to the measuring element and a comparison with other types of these devices, including the reliability parameters.

Author

A86-49149

APPLICATION OF STRAIN GAUGE METHODS TO DETERMINATION OF IN-FLIGHT LOADS OF STRUCTURE GROUPS OF SMALL TRANSPORT AIRCRAFT [APLIKACE TENZOMETRICKYCH METOD PRI STANOVENI LETOVYCH ZATIZENI KONSTRUKCNIH CELKU MALEHO DOPRAVNIHO LETADLA]

P. MARJANEK Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1986, p. 167-112. In Czech. refs

The paper indicates procedures allowing examination of the actual load in the structure groups of aircraft. The in-flight strain gauge measurements are difficult, and, as a rule, allow the use of only very restricted apparatus. For this reason, it is necessary to accept certain simplifications which need not practically have an impact on the quality of information obtained if they are involved in the measuring method. The expression of actual loads

necessitates the calibration of the strain gauge installation in an aircraft. The quality of calibration affects the quality of measuring results in a decisive degree. The procedure is accompanied with illustrations of tests performed on a small transport aircraft.

Author

A86-49498

SMART PROBES FOR AIR DATA

Avionics (ISSN 0273-7639), vol. 10, June 1986, p. 8-11.

The characteristics of a distributed air data system (DADS) are described and compared to a central air data system. The DADS is an integrated system of sensors, transducers, and electronics, and is easy to expand and modify. The operation of the avionics computer utilized to process the air data is discussed. The output provided by the Rosemount instrument of the DADS is examined.

I.F.

N86-31580# Federal Aviation Administration, Washington, D.C. Program Engineering and Maintenance Service.

CHARACTERISTICS OF ALTITUDE ERROR AT REDUCED QUANTIZATION Final Report

G. A. WONG Aug. 1986 33 p
(FAA/PM-86/35) Avail: NTIS HC A03/MF A01 CSCL 01D

An analysis of the impact of reducing the quantization level on the altitude error produced by the altimetry system is described. Specifically, the mean and the standard deviation of the altitude error at the output of the aircraft's onboard quantization device are derived assuming altitude error at its input is normally distributed. The formulae derived are very general, exact, and applicable to all ranges of input statistics and quantization levels. A computer program was written to evaluate the impact of reduced quantization for a wide range of input error standard deviation and several quantization levels. Additionally, a comparison is made between the commonly used and approximate uniform distribution model method and the exact formulae derived herein for calculating the quantized altitude error.

Author

N86-31581# Koninklijk Inst. voor de Marine, Den Helder (Netherlands).

FLIGHT DATA RECORDERS (FDR) AND/OR COCKPIT VOICE RECORDERS (CVR) IN THE LOCKHEED ORION P-3C UPDATE 2 [FDR EN/OF CVR IN DE LOCKHEED ORION P-3C UPDATE 2]

J. J. COORENS Jul. 1984 136 p In DUTCH and ENGLISH
(ETN-86-97395) Avail: NTIS HC A07/MF A01

Installation of Flight Data Recorder/Cockpit Voice Recorder (FDR/CVR) combinations in the P-3C Update aircraft is discussed. Requirements, design and development, and feasibility aspects of FDRs and CVRs are treated. Examples of existing systems (e.g., the U.S. Navy Universal Locator Airborne Data Systems, and the solid-state FDR) are given. Aircraft accident relevant information, necessary adaptations of the P-3 aircraft, and feasibility were investigated. Because of the high FDR cable system costs, installation of only a CVR is concluded to be the most feasible solution.

ESA

N86-32431# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

FLIGHT TEST INSTRUMENTATION USED IN THE FOKKER F27 AND F28 DEVELOPMENT AND CERTIFICATION FLIGHT PROGRAM

J. T. M. VANDOORN Sep. 1984 56 p Lecture presented at AGARD Consultancy Mission, Lisbon, Portugal, 10 Apr. 1984
(NLR-MP-84023-U; B8661087; ETN-86-97665) Avail: NTIS HC A04/MF A01

The development of the Fokker F27 turboprop and F28 turbofan short-haul airliners and the flight test programs for these two aircraft types are reviewed. The flight test instrumentation systems designed to meet the requirements of these programs and which were used throughout the years of F27 and F28 development are described.

ESA

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A86-47786**FLIGHT TESTING OF GENERAL ELECTRIC HIGH BYPASS ENGINES EVOLUTION AND REVOLUTION**

S. H. HOLT (General Electric Co., Cincinnati, OH) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 2.6-1 to 2.6-7.

Beginning with the introduction of the first bypass turbofan engine, the TF39, its manufacturer has conducted flight tests aboard highly instrumented versions of the B-52, B707, A300B2, and Caravelle aircraft. The B707 and A300B2 aircraft used are noteworthy in their incorporation of extensive digital data gathering systems within the converted passenger cabin volumes. Attention is given to the aircraft testbed modification and instrumentation plans currently being considered for the flight testing of the ultrahigh bypass 'Unducted Fan' (UDF) engine; a B727 will be used, with the UDF installed as the no. 3 engine. O.C.

A86-48101#**A JET FUEL STARTER AND EXPENDABLE TURBOJET**

C. RODGERS (Sundstrand Turbomach, San Diego, CA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (ASME PAPER 86-GT-1)

High power density, low cost and modest technology levels are the common constraints of the small gas turbine jet fuel starter and expendable turbojet presented. The F-16's T-72 jet fuel starter, of which over 15,000 units have been manufactured to date, offered an inherently cost-effective basis for the achievement of an expendable turbojet. The single-shaft gas turbine configuration used employs a single centrifugal compressor and a radial inflow turbine. O.C.

A86-48102#**POWER TURBINE VANE RING (PT6 ENGINE) REPAIR DEVELOPMENT**

N. SOURIAL (Pratt and Whitney Canada, Inc., Longueuil) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. (ASME PAPER 86-GT-2)

An evaluation is made of the damage typically encountered in the PT6 turboprop engine's power turbine vane ring, as well as to the technology used to repair the damage. Attention is given to solution heat treatment, brazing, vacuum furnace cycling, the plasma spraying apparatus and its operations, grit blasting, and coating quality assurance. The vane ring is composed of a cast cobalt alloy. O.C.

A86-48103#**THE USE OF SURFACE STATIC PRESSURE DATA AS A DIAGNOSTIC TOOL IN MULTISTAGE COMPRESSOR DEVELOPMENT**

H. D. WEINGOLD and R. F. BEHLKE (United Technologies Corp., Engineering Div., East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. refs (ASME PAPER 86-GT-3)

A technique has been developed to analyze static pressure distributions obtained from the surfaces of stators in a multistage compressor to determine incident Mach number and flow angle and the turning and streamtube contraction for the individual stator sections. This data analysis technique permits this nonintrusive type of pressure measurement to be used to optimize the design of stator airfoils during the development phase of a multistage

compressor and, in the development of analytic compressor representations, to segregate rotor and stator performance and to improve the modeling of endwall blockage. The value of this technique has been demonstrated in cascade testing of compressor airfoils, in single-stage and three-stage rig testing, and in engine testing. Author

A86-48116#**ENGINE COMPONENT LIFE PREDICTION METHODOLOGY FOR CONCEPTUAL DESIGN INVESTIGATIONS**

J. D. CYRUS (U.S. Navy, Naval Air Development Center, Warminster, PA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (ASME PAPER 86-GT-24)

The increasing emphasis on engine durability requires that an analytical capability be acquired to assess engine component lives during the conceptual/preliminary design phases. A generalized methodology has been developed to provide a fundamental understanding of the impact of engine design decisions, material selections, and a detailed consideration of engine usage for critical gas turbine engine components. a.

A86-48119#**OPERATION OF THE CT7 TURBOPROP ENGINE AS AN AUXILIARY POWER UNIT (APU)**

J. D. STEWART (General Electric Co., Aircraft Engine Business Group, Lynn, MA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. (ASME PAPER 86-GT-28)

The recently developed CT7 turboprop engine has been designed so that it may be used as either an APU or primary propulsion unit. This 1700-shp class commuter/executive aircraft powerplant furnishes bleed air for the aircraft's environmental control system and electrical power for ground operations, thereby reducing the higher cost, weight, and fuel consumption of an APU. A propeller brake had to be developed in order to lock the propeller and power turbine system; in addition, the engine is designed to operate at or near idle while generating large quantities of bleed air and electrical power. O.C.

A86-48124#**LIFE CYCLE COST METHODOLOGY FOR PRELIMINARY DESIGN EVALUATION**

E. J. REED (Pratt and Whitney, West Palm Beach, FL) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. (ASME PAPER 86-GT-37)

Attention is given to the Engine/Airframe Generalized LCC Evaluator, or 'Eagle' methodology for advanced engines, which simplifies the design engineering process that must be conducted for the configuration/cost/performance tradeoffs that will determine impacts on total weapon system life cycle costs. A critical element of Eagle is its interactive engine/airframe sizing methodology. A mission analysis program consisting of a group of modular subroutines linked to simulate the conduct of a mission is also used. O.C.

A86-48125#**DURABILITY AND DAMAGE TOLERANCE ASSESSMENT OF THE TF34-100 ENGINE**

J. S. OGG (USAF, Wright-Patterson AFB, OH) and R. R. REINHOLD (General Electric Co., Lynn, MA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 15 p. refs (ASME PAPER 86-GT-38)

A detailed structural durability and damage tolerance assessment has been conducted for the TF34-100 engine used by the U.S. Air Force's A-10 close air support aircraft, and a comprehensive Structural Maintenance Plan is formulated on the basis of the evaluation results obtained. The Plan identifies both current and future maintenance actions required for maximum flight

safety, entailing component inspection and replacement at defined intervals, inspection systems, preferred modifications and reworkings, as well as a life growth plan for the extension of useful life to the extent of 8000 A-10 mission hours. O.C.

A86-48132#
ENGINE CONTROL RELIABILITY AND DURABILITY IMPROVEMENT THROUGH ACCELERATED MISSION ENVIRONMENTAL TESTING

W. J. DAVIES (Pratt and Whitney, West Palm Beach, FL) and R. W. VIZZINI (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 4 p. refs (ASME PAPER 86-GT-52)

Future military aircraft engine control systems will require the satisfaction of mission reliability criteria by means of system redundancy and accelerated environmental testing. Attention is given to the 10,000-hr Combined Environment Reliability Testing program, recently undertaken for dual full-authority digital electronic controls that are connected by a fiber-optic data link, and simulating a composite F-14 mission profile. These units were also subjected to periodic high vibration levels such as would be experienced after foreign object damage and salt spray testing. O.C.

A86-48141*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTATIONAL ENGINE STRUCTURAL ANALYSIS

C. C. CHAMIS and R. H. JOHNS (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 12 p. Previously announced in STAR as N86-19663. refs (ASME PAPER 86-GT-70)

A significant research activity at the NASA Lewis Research Center is the computational simulation of complex multidisciplinary engine structural problems. This simulation is performed using computational engine structural analysis (CESA) which consists of integrated multidisciplinary computer codes in conjunction with computer post-processing for problem-specific application. A variety of the computational simulations of specific cases are described in some detail in this paper. These case studies include: (1) aeroelastic behavior of bladed rotors, (2) high velocity impact of fan blades, (3) blade-loss transient response, (4) rotor/stator/squeeze-film/bearing interaction, (5) blade-fragment/rotor-burst containment, and (6) structural behavior of advanced swept turboprops. These representative case studies are selected to demonstrate the breath of the problems analyzed and the role of the computer including post-processing and graphical display of voluminous output data. Author

A86-48144#
HEAT MANAGEMENT IN ADVANCED AIRCRAFT GAS TURBINE ENGINES

G. L. BRINES and D. E. GRAY (Pratt and Whitney, East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. (ASME PAPER 86-GT-76)

This paper summarizes current and projected heat management techniques within aircraft gas turbines. Each of the primary heat sources is individually considered, including the thermodynamic cycle sources of fuel combustion and air compression, and the parasitic sources of friction, oil churning and rotor windage. For each source, the problem is presented, and solutions - both present and future - are offered. Heat management within low spool reduction gearing is also discussed because of the high probability of an advanced high speed turboprop and geared high bypass ratio turbofan propulsion system in the future. Author

A86-48148#
DEVELOPMENTS IN NEW GAS TURBINE ENGINE DEMONSTRATOR PROGRAMS

E. T. JOHNSON (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) and D. D. KLASSEN (General Electric Co., Lynn, MA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p.

(ASME PAPER 86-GT-80)

Achievement evaluations are made for gas turbine engine technology demonstration programs undertaken by the U.S. Army's Aviation Applied Technology Directorate since 1967. The four programs in question concerned a 1500-hp demonstrator engine, a 200-800 hp small turbine advanced gas generator, the 800-hp Advanced Technology Demonstrator Engine (1977), and the 6000-hp Modern Technology Demonstrator Engine (1983). Attention is given to experiences and lessons learned concerning development program management practices. O.C.

A86-48156#
SUBSONIC/TRANSONIC STALL FLUTTER INVESTIGATION OF AN ADVANCED LOW PRESSURE COMPRESSOR

Y. M. EL-AINI, C. E. MEECE (Pratt and Whitney, Structures Technology Group, West Palm Beach, FL), and H. R. BANKHEAD (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (Contract F33615-79-C-2087)

(ASME PAPER 86-GT-90)

The subsonic/transonic stall flutter characteristics of the Pratt & Whitney PW1120 Low Pressure Compressor (LPC), recently have been defined through fan rig tests and a full-scale engine test. Flutter data analyses, based on both empirical and analytical methods, have shown excellent correlations between test results and predictions. While the LPC was demonstrated to be flutter-free over its entire flight envelope, the study indicates the need for continued research in transonic unsteady aerodynamics, particularly, the effects of passage shocks and large leading edge incidence. Author

A86-48163*# Massachusetts Inst. of Tech., Cambridge.
ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF THE COUPLED BLADED DISK/SHAFT WHIRL OF A CANTILEVERED TURBOFAN

E. F. CRAWLEY, E. H. DUCHARME, and D. R. MOKADAM (MIT, Cambridge, MA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 9 p. refs

(Contract NAG3-200)

(ASME PAPER 86-GT-98)

A simple analytical model for the structural dynamics of a rotating flexible blade/rigid disk/flexible cantilevered shaft system yields the equations of motion expressed in the rotating frame, showing that the blade's one-nodal diameter modes dynamically couple to the rigid body whirling motion of the shaft-disk system. This analytical model is correlated with the results of a structural dynamic experiment performed on an aeroelastic rotor fan that is similar to a high bypass ratio shroudless turbofan. The agreement between the predicted and experimental natural frequencies is good, and suggests significant interaction of the one-nodal diameter blade modes with the shaft-disk modes. O.C.

A86-48164*# Purdue Univ., West Lafayette, Ind.
SPLITTER BLADES AS AN AEROELASTIC DETUNING MECHANISM FOR UNINSTALLED SUPERSONIC FLUTTER OF TURBOMACHINE ROTORS

D. A. TOPP and S. FLEETER (Purdue University, West Lafayette, IN) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 9 p. NASA-supported research. refs

(ASME PAPER 86-GT-99)

Splitter plates usable as aeroelastic detuner devices for supersonic flutter in turbomachinery, through the introduction of

both aerodynamic and structural detuning to enhance aeroelastic stability, are presently considered by a mathematical model. The model demonstrates that aerodynamic detuning is due to both the alternate circumferential spacing of the full chord airfoils and the variable circumferentially spaced splitters between each pair of full chord airfoils. Structural detuning is based on the lower natural frequencies of the splitters, by comparison with the full chord airfoils. The model's application to two unstable rotors demonstrates enhanced torsion mode flutter stability through the incorporation of splitters, where the critical parameters are chord length and the circumferential and axial locations of the splitters.

O.C.

A86-48165#

COMPARISON OF METHODS FOR LIFETIME CALCULATIONS OF HIGHLY LOADED AERO-ENGINE DISCS

R. HEFELE, G. KAPPLER, and D. RIST (Muenchen, Technische Universitaet, Munich, West Germany) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (ASME PAPER 86-GT-102)

The requirements for low weight-to-thrust ratios of modern aero-engines has led to high structure loads and design of parts in the range of low cycle fatigue. In order to ensure high reliability and optimized time between overhaul, methods to calculate accurately the durability of parts are of great interest. For a highly loaded compressor disk of a fighter engine, the lifetime was calculated using the nominal stress method and the maximum local strain concept. The nominal and maximum local stresses and strains were calculated with a finite-element program which was extended to consider plastic deformation of materials. The reference load cycle, which was the same for both methods, was derived from actual load measurements during flight missions. The comparison of the results shows the region of validity of both methods and suggests the application of a modified nominal stress method. Two proposals for improving the nominal stress method by superseding the Neuber-Hyperbolic rule and modifying the mean stress influence in the Goodman diagram are discussed. Author

A86-48166#

THE EFFECT OF A DOWNSTREAM ROTOR ON THE MEASURED PERFORMANCE OF A TRANSONIC TURBINE NOZZLE

R. G. WILLIAMSON (National Research Council of Canada, Ottawa), S. H. MOUSTAPHA, and J. P. HUOT (Pratt and Whitney Canada, Inc., Longueuil, Canada) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p. refs (ASME PAPER 86-GT-103)

Two nozzle designs, involving the same low aspect ratio, high turning angle vanes, and differing in outer wall contour, were tested over a range of exit Mach numbers up to supersonic values. The experiments were conducted on a large-scale, full annular configuration with and without a representative rotor downstream. Nozzle performance was found to be significantly affected by rotor operation, the influence depending on the detailed characteristics of the nozzle flow field, as well as on the design and operation of the rotor itself. It is suggested that performance evaluation of low aspect ratio nozzles of high turning angle may require appropriate testing with a rotor.

Author

A86-48180#

ACCELERATION PERFORMANCE OF HELICOPTER ENGINES

M. R. MALTBY (Rolls-Royce, Ltd., Leavesden, England) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 5 p. (ASME PAPER 86-GT-121)

More demanding requirements in helicopter maneuverability and safety call for enhanced acceleration behavior in helicopter gas turbine engines. Attention is presently given to such factors as compressor characteristics, steady-state running and transient running lines, surge (or stall), surge line and surge margin, and compressor transient modeling techniques. An analysis of these parameters allows an engineer to define requirements in terms of

power vs. time in order to find the most appropriate means of achieving them; these means could involve either surge margin increases or a reduction of surge margin requirements through the modification of compressor flow/speed characteristics. O.C.

A86-48202#

THE PERFORMANCE OF A REVERSE FLOW COMBUSTOR USING JP 10 FUEL

J. WINTER and K. H. MADEN (Lucas Aerospace, Ltd., Combustion Technology and Engineering Centre, Burnley, England) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (ASME PAPER 86-GT-146)

The test rig performance of a fan spray fuel injection reverse flow combustor for a 500-shp engine using JP 10 fuel is compared with that using aviation kerosene (Avtur). JP 10 fuel is a pure hydrocarbon with a hydrogen content of 11.8 percent compared with some 13.8 percent for aviation kerosene. The comparative performance data reported include fuel injector atomization characteristics, exhaust combustion efficiencies and emissions, exhaust temperature distributions, flame tube metal temperatures and simulated pressure altitude relight and combustion stability over a range of conditions up to a simulated altitude of 6.1 km.

Author

A86-48211#

PREMIXING GAS AND AIR TO REDUCE NOX EMISSIONS WITH EXISTING PROVEN GAS TURBINE COMBUSTION CHAMBERS

B. BECKER, P. BERENBRINK, and H. BRANDNER (Kraftwerk Union AG, Reaktortechnik, Muelheim an der Ruhr, West Germany) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. refs

(ASME PAPER 86-GT-157)

Attention is given to a gas turbine combustion chamber design in which the primary airflow is supplied through the burner section's swirler, thereby rendering the uniform addition of natural gas to this air flow, before it enters the combustion zone, straightforward. This feature results in particularly low NO(x) emissions as long as the air/fuel ratio is maintained within suitable bounds. Combustion chambers currently in service can be retrofitted with this premixing equipment to reduce NO(x) output levels to about 1/3 of original values.

O.C.

A86-48220#

A STUDY ON NOX EMISSIONS FROM GAS TURBINE COMBUSTOR

M. SASAKI and T. ITOH (Nissan Motor Co., Ltd., Central Research Laboratories, Yokosuka, Japan) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 5 p. refs (ASME PAPER 86-GT-168)

Diffusion flame and two-stage ceramic gas turbine combustor units are presently tested using JIS No. 2 Diesel oil, heavy B oil, and water-into-fuel emulsions of the two. While CO, HC and smoke emissions were exceptionally low in both cases due to the higher-than-normal inlet temperature of up to 1200 K, NO(x) levels were high in the case of the diffusion flame combustor design. The use of kerosene reduced NO(x) by lowering fuel nitrogen levels. With such low nitrogen fuels, the conversion fraction of fuel nitrogen to NO(x) is noted to be minimized by maintaining a somewhat rich equivalence ratio in the first stage of the two-stage combustor.

O.C.

A86-48224*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TOWARD IMPROVED DURABILITY IN ADVANCED COMBUSTORS AND TURBINES - PROGRESS IN PREDICTION OF THERMOMECHANICAL LOADS

D. E. SOKOLOWSKI and C. R. ENSIGN (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 13 p. refs

(ASME PAPER 86-GT-172)

NASA is sponsoring the Turbine Engine Hot Section Technology (HOST) Project to address the need for improved durability in advanced combustors and turbines. Analytical and experimental activities aimed at more accurate prediction of the aerothermal environment, the thermomechanical loads, the material behavior and structural responses to such loading, and life predictions for high temperature cyclic operation have been underway for several years and are showing promising results. Progress is reported in the development of advanced instrumentation and in the improvement of combustor aerothermal and turbine heat transfer models that will lead to more accurate prediction of thermomechanical loads.

Author

A86-48225#

IMPACTION EFFICIENCIES OF EVAPORATING KEROSENE DROPLETS ON VEE-GUTTER FLAME STABILIZER

Q.-F. ZHANG, Z.-K. KONG, and Q.-H. ZHOU (Nanjing Aeronautical Institute, People's Republic of China) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. refs

(ASME PAPER 86-GT-174)

The numerical solution of equations for the flow field around a vee-gutter similar to those used in aircraft afterburners has, in conjunction with a droplet evaporation model, yielded predictions of the impact efficiency of evaporating kerosene droplets. Dimensional analysis was then conducted to obtain an expression for the calculation of droplet impact efficiency. It is found that the key factor influencing the efficiency of this phenomenon is initial droplet diameter; efficiency, which is proportional to the 1.44 power of initial diameter, decreases with increasing ambient temperature and pressure and increases with stream velocity.

O.C.

A86-48230#

A GENERAL COMPUTATIONAL METHOD FOR SIMULATION AND PREDICTION OF TRANSIENT BEHAVIOR OF GAS TURBINES

T. SCHOEIRI (Brown, Boveri et Cie. AG, Baden, Switzerland) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 11 p. refs

(ASME PAPER 86-GT-180)

This paper describes a general computational method for predicting the dynamic behavior of gas turbines and their components during transient processes of the most varied kinds. Starting from the conservation laws of fluid and thermodynamics, formulas are derived with which non-stationary processes in the most important components of the gas turbine can be accurately predicted. As an example, the transient behavior of an open-cycle gas turbine with extreme changes in load is calculated. The comparison between the calculations and measurements demonstrates the accuracy and the reliability of the computational method. Although this method has so far been applied only to a broad range of power-generating gas turbines extending from open-cycle turbines to air storage turbines, it is also suitable for the simulation of aircraft gas turbines.

Author

A86-48231*# John Deere Technologies International, Inc., Wood-Ridge, N.J.

STRATIFIED CHARGE ROTARY ENGINE FOR GENERAL AVIATION

R. E. MOUNT (John Deere Technologies International Inc., Rotary Engine Div., Wood-Ridge, NJ), A. M. PARENTE (Avco Corp., Avco Lycoming Div., Williamsport, PA), and W. F. HADY (NASA, Lewis Research Center, Cleveland, OH) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 10 p. refs

(ASME PAPER 86-GT-181)

A development history, a current development status assessment, and a design feature and performance capabilities account are given for stratified-charge rotary engines applicable to aircraft propulsion. Such engines are capable of operating on Jet-A fuel with substantial cost savings, improved altitude capability, and lower fuel consumption by comparison with gas turbine powerplants. Attention is given to the current development program of a 400-hp engine scheduled for initial operations in early 1990. Stratified charge rotary engines are also applicable to ground power units, airborne APUs, shipboard generators, and vehicular engines.

O.C.

A86-48241#

POWER LEVEL INFLUENCE ON ARCHITECTURE OF SMALL HELICOPTER TURBOSHAFT ENGINES

M. GIRAUD (Turbomeca, S.A., Bordes, France) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p.

(ASME PAPER 86-GT-191)

The considerable differences that exist among the members of the presently examined family of helicopter turboshaft engines, especially among their aerodynamic components, are noted to have their bases in simple thermodynamic considerations. The engines in question are of the 1500-1600, 900-1000, 600-700, and 300-400 kW classes; all are of two-shaft configuration, with an inverse-flow combustor and a final centrifugal compressor stage. Size reductions in compressors and turbines are generally accompanied by efficiency decreases, entailing lower compression ratios for optimum specific power and fuel consumption. Attention is given to the effects of turbine entrance temperature and compression ratios on engine architecture.

O.C.

A86-48252#

FUEL EFFECTS ON AIRCRAFT COMBUSTOR EMISSIONS

C. M. REEVES (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) and A. H. LEFEBVRE (Purdue University, West Lafayette, IN) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 10 p. refs

(ASME PAPER 86-GT-212)

Results of an analytical program to determine the effects of broad variations in fuel properties on the pollutant emissions generated by several prominent turbojet engine combustion systems, including both tubo-annular and annular configurations, are presented. Measurements of mean drop size conducted at representative engine operating conditions are used to supplement the available experimental data on the effects of combustor design parameters, combustor operating conditions, and fuel type, on pollutant emissions. The results of the study indicate that the fuel's physical properties that govern atomization quality and evaporation rates have a significant effect on the emissions of carbon monoxide and unburned hydrocarbons. Analysis of the available experimental data shows that the influence of fuel chemistry on the emissions of carbon monoxide, unburned hydrocarbons, and oxides of nitrogen, is small. Smoke emissions are found to be strongly dependent on combustion pressure, primary-zone fuel/air ratio, and the mode of fuel injection (pressure atomization or airblast). Fuel chemistry, as indicated by hydrogen content, is also important. Equations are presented for the correlation and/or prediction of exhaust emissions in terms of combustor size, combustor geometry, engine operating conditions, fuel spray characteristics, and fuel type.

Author

A86-48278*# McDonnell Aircraft Co., St. Louis, Mo. **DEVELOPMENT OF HIDECA ADAPTIVE ENGINE CONTROL SYSTEMS**

R. J. LANDY, W. A. YONKE (McDonnell Aircraft Co., Saint Louis, MO), and J. F. STEWART (NASA, Flight Research Center, Edwards, CA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 9 p. refs (ASME PAPER 86-GT-252)

The purpose of NASA's Highly Integrated Digital Electronic Control (HIDECA) flight research program is the development of integrated flight propulsion control modes, and the evaluation of their benefits aboard an F-15 test aircraft. HIDECA program phases are discussed, with attention to the Adaptive Engine Control System (ADECS I); this involves the upgrading of PW1128 engines for operation at higher engine pressure ratios and the production of greater thrust. ADECS II will involve the development of a constant thrust mode which will significantly reduce turbine operating temperatures. O.C.

A86-48296# **AN APPROACH TO AN INTEGRATED CONTROL SYSTEM FOR A MODERN FIGHTER AIRCRAFT ENGINE**

J. LEMMIN (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 7 p. (ASME PAPER 86-GT-277)

In the field of today's military aircraft engines, the engine control system consists in most cases of hydromechanical controls with an electronic supervisory system. This type of control makes the integration of engine and aircraft systems rather difficult. Even with the Tornado engine, which features a full authority electronic engine controller, only initial steps in systems integration are realized. With the introduction of digital electronics into both the engine control and the aircraft systems, together with the availability of data highway systems, large scale systems integration can be envisaged on future fighter aircraft, with the resultant improvement in overall weapon system performance. This paper puts forward a proposal for a control concept for a reheated fighter engine, and outlines possibilities for integration with aircraft systems. Author

A86-48302# **THE GTPC36-300 - A GAS TURBINE AUXILIARY POWER UNIT FOR ADVANCED TECHNOLOGY TRANSPORT AIRCRAFT**

L. M. STOHLGREN (Garrett Turbine Engine Co., Phoenix, AZ) and L. D. WERNER (Garrett GmbH, Raunheim am Main, West Germany) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 9 p. (ASME PAPER 86-GT-285)

The Garrett GTPC36-300 Series Auxiliary Power Unit is being developed for use on advanced technology transport aircraft in the 150-passenger size class. The first application will be the Airbus Industries A320 Aircraft. The APU uses a 6:1 pressure ratio, single-stage compressor and turbine, driving a single-stage load compressor and accessory gearbox. The 480 horsepower APU delivers compressed air to the aircraft pneumatic system and drives a customer furnished 90 kva, 24,000 rpm electrical generator. State-of-the-art aerodynamics, materials, and digital electronics are used to give the user-airlines an APU delivering maximum performance with minimum envelope, weight, and cost of ownership. Author

A86-48312# **ENGINE CONDITION MONITORING AT KLM ROYAL DUTCH AIRLINES**

P. H. C. ADAMSE (KLM Royal Dutch Airlines, Engineering and Maintenance Div., Schiphol Airport, Netherlands) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. (ASME PAPER 86-GT-300)

This paper describes the development of an engine condition monitoring system at a major airline. The objectives and philosophy

of the systems are discussed, as well as the current and future functions and the use in the airline organization. Author

A86-48369 **FIGHTER POWER FOR THE 1990S**

B. SWEETMAN, P. CONDOM, and C. GILSON Interavia (ISSN 0020-5168), July 1986, p. 731-733, 736-738.

A comprehensive evaluation is made of fighter engine technology development status in Western Europe and the U.S., in view of emerging and unprecedentedly stringent requirements in thermodynamic efficiency, low fuel consumption, high power/weight ratio, and low maintenance/high reliability. Major component development efforts are noted in highly loaded stage axial flow compressor designs, vectorable/reversible-thrust nozzles, V/STOL propulsion system configurations, turbine blade cooling schemes, and variable engine cycles. All next-generation engines under development, such as the French M88, British XG-40, and American GE37 and PW5000, are low-bypass turbofans; the latter two are expected to yield thrust/weight ratios of 9-10:1. O.C.

A86-48757 **THE ADJUSTMENT OF A TURBOJET ENGINE COMPRESSOR BY THE ROTATION OF THE GUIDE VANES WITH THE OBJECTIVE OF REDUCING FUEL CONSUMPTION DURING THROTTLE OPERATION [REGULIROVANIE KOMPRESSORA TURBOREAKTIVNOGO DVIGATELIA POVOROTOM NAPRAVLIAUSHCHIKH APPARATOV S TSEL'JU SNIZHENIYA RASKHODA TOPLIVA NA DROSSEL'NYKH REZHIMAKH]**

A. G. KUKINOV and A. A. LUNEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 1, 1985, p. 54-60. In Russian.

The problem of the optimum control of the compressor of a turbojet engine by means of adjustable guide vanes is formulated and analyzed. The possible fuel economy achieved by turning the guide vanes is estimated with reference to two engines, one with a single-shaft compressor and the other with a twin-shaft compressor. V.L.

A86-48979# **FUTURE TRENDS IN PROPULSION**

S. C. MILLER and H. W. BENNETT (Rolls-Royce, Ltd., London, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 25-40.

The prediction of future trends in propulsion also requires an examination of past achievements. Continued progress is foreseen. In both civil and military fields, aircraft speed is an important parameter determining the configuration and technology of the engine. In civil designs, increase in bypass ratio will improve fuel consumption, the exact configuration being speed-dependent, but the advance must be achieved in a cost-effective way. In military designs, while the configuration may be less likely to change, major improvements in weight and cost will appear. V/STOL aircraft will move from subsonic to supersonic. Hypersonic propulsion will require radical new concepts. Computer assistance will increasingly apply to all phases, from design to production. Author

A86-49064# **PROPOSED CONTROL OF COMPRESSOR STALL BY PRESSURE PERTURBATION AND BLADE DESIGN**

B. S. THORNTON, L. C. BOTTEN, and J. P. GOSTELOW (New South Wales Institute of Technology, Sydney, Australia) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 820-826. refs

A method is proposed for suppressing stall and stall flutter in an axial flow compressor by injecting upstream perturbations. Evidence from another field shows that the addition of particular noise perturbations to a bifurcating system can greatly reduce the entropy increase and yield power spectra with several pronounced frequency peaks. Problems are considered in achieving downstream perturbations having a spectrum consistent with stability requirements under perturbations for the non-linear blade dynamics. The requirements may be modified by blade design

parameters. The controlled injection of turbulence into the upstream flow has been shown to have the desired effect of suppressing laminar separation. Stall suppression devices for fans based on the recirculation of turbulent tip region fluid are successful but are not well understood. The suggestions of this paper should provide a hypothetical basis for the design of these devices and provision of a modified endogenous recirculation procedure. Author

A86-49079#

ADVANCES IN TURBINE TECHNOLOGY

H. TUBBS (Rolls-Royce, PLC, Bristol, England) and M. J. HOLLAND IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 957-966. refs

Progress made toward achieving a turbine technology system using engineering which meets the requirements of modern military or commercial engine programs is described. The requirements regarding castings, cooling inserts and attachments, impingements and film cooling holes, machined locations, and cooling air supply pressure are discussed, and the overall objectives in the management of turbine technology activity in engineering are summarized. The implementation of turbine technology in the modern aircraft gas turbine is addressed, reviewing the relevant engineering philosophy and summarizing the functions and programs of the TACITUS system. The role of experiments in the advancement of turbine technology with regard to applied research, turbine aerodynamic component rig tests, core engine tests, and engine tests is addressed. Major improvements achieved in HP turbine blade cooling and service life, turbine efficiency, and team-building and work-sharing are reviewed. C.D.

A86-49088#

THE M53 TURBOFAN CONTROL SYSTEM - A STRONG BASIS FOR THE DEVELOPMENT OF THE FUTURE DIGITAL CONTROL SYSTEMS

P. GALMICHE (SNECMA, Melun-Villaroche, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1069-1074.

Specific examples are used to demonstrate the introduction of new engine control concepts into the M53 turbofan control system. These concepts are: full authority control through a digital computer, redundancy, failure detection and identification, and assistance to maintenance. The architectures of the systems embodying these concepts are shown and discussed. C.D.

A86-49089#

DIGITAL ENGINE CONTROL UNITS FOR AN FIGHTER ENGINE AND AN AUXILIARY POWER UNIT - A COMPARISON

G. DAHL (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1075-1083. refs

The reasons for requiring different controllers for different engine types are explained by comparing the requirements and technical solutions for the controllers of an auxiliary power unit and a fighter engine. The design aims of the controllers, the tasks which they must fulfill, and the requirements they must meet in order to fulfill these tasks are summarized. The system concepts, input/output requirements, (PUS) and other hardware elements of both types of controllers are described. The software configurations are addressed, including the operating system, the applications software, drive software and standard routines, safety and reliability software, BIT for monitoring hardware and software, and exerciser software. It is shown that only the CPU and some hardware circuits and software modules are of exactly the same design in the two controllers. C.D.

A86-49090#

CASE STUDIES OF THE EFFECTS ON NON-LINEARITIES ON THE ACCURACY OF GAS TURBINE CONTROL

D. M. TURNER (Rolls-Royce, Ltd., Derby, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1084-1090.

A set of three case studies is used to demonstrate the loss in accuracy which arises in control systems when nonlinearity and signal noise effects are combined. All three are drawn from experiences in the development of microprocessor-based gas-turbine fuel control systems. The first two arise due to nonlinearities in the control logic implemented in the microprocessor and have been solved by modification to the logic; the third arises as a result of nonlinearity in the fuel system. Various solutions are presented, and it is concluded that a combination of system nonlinearity and measurement noise is the norm rather than the exception in practical control systems. Related accuracy losses can be avoided through the increased use of simulation techniques. K.K.

A86-49091#

A PROPPAN STATUS REPORT

J. MORRIS (Douglas Aircraft Co., Long Beach, CA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1091-1098.

The economic viability of the propfan or Ultra High Bypass (UHB) engine concept is discussed considering such factors as future fuel prices and interest rates. Different design approaches (e.g., the derivative route versus all-new designs) are examined. A brief analysis is made of indicated capacity selection and related potential market. Technical, design, and configuration problems are also examined in regard to airport and en route noise, aerodynamic issues including flying qualities and deep stall, structural dynamics, acoustics, and sonic fatigue. A demonstrator program is finally outlined with projected time schedule leading to technology readiness for production as the unique airframe problems are being solved. Author

A86-49092#

PROPPAN AND TURBOFAN - ANTAGONISM OR SYNTHESIS

H. GRIEB and D. ECKARDT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1099-1110.

Investigations are carried out which show that the desired combination of the positive properties of a turbofan with the advantages of the open contrarotating propfan results in an engine concept which ensures a clear reduction in the overall propulsion weight. The resulting engine has a counterrotation shrouded front fan with variable-pitch blades; these allow for higher flow density in comparison with the turbofan and higher thrust loading in comparison with the open propfan. This engine is characterized by a very high bypass ratio and favorable acoustic properties which allow for conventional underwing and tail installation. K.K.

A86-49111#

THEORETICAL CONSIDERATIONS OF THE SPECIFIC IMPULSE OF RAMJET ENGINES

A. GANY (Technion - Israel Institute of Technology, Haifa) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1319-1325.

The present theoretical analysis of an ideal ramjet's specific impulse attempts to establish a measure of engine performance under various conditions, noting peak performance situations, primary trends in operating parameter variations, and the practical consequences of various operational modes. Attention is given to results obtained which bear on the influence of fuel/air ratio, fuel energy, combustion gas properties, and flight Mach number on specific impulse-designated performance. Ideal ramjet maximum

07 AIRCRAFT PROPULSION AND POWER

theoretical specific impulse is achieved when the fuel/air ratio approaches zero; this maximum is linearly proportional to the heat of combustion/unit mass of fuel. The analysis, which yields the optimum flight Mach number for any thrust level and fuel/air ratio, demonstrates that optimal flight Mach number increases with rising fuel/air ratio and fuel energy. O.C.

A86-49112#

A COMPARISON OF POD AND TAIL MOUNTED RAMJETS

D. R. M. ARENS and H. V. HATTINGH (Stellenbosch, University, Republic of South Africa) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1326-1330.

A performance capability assessment is conducted for a remotely piloted vehicle configuration which employs an annular tail-mounted ramjet powerplant. A central boundary layer bleed duct is incorporated to improve shock inlet aerodynamics. Satisfactory operation was obtained in a directly connected test bed installation simulating supersonic operation at sea level. Pod-mounted ramjet performance in the same conditions is compared. O.C.

A86-49113#

REGRESSION RATE STUDY FOR A SOLID FUEL RAMJET

G. SCHULTE and R. PEIN (DFVLR, Institut fuer chemische Antriebe und Verfahrenstechnik, Hardthausen am Kocher, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1331-1336. refs

The combustion behavior of a solid fuel ramjet is experimentally assessed under various operating conditions, with attention to the fuel grain recession rates of a variety of thrust maximization-optimized pure hydrocarbon and metal additive-employing fuels. HTPB is taken as the baseline fuel. The fuel grains take the form of a cylindrical shell whose center volume doubles as the combustion chamber; inlet air oxidizes the fuel vapor being exuded by the cylinder's internal surface. Attention is given to some aspects of the manufacturing procedures and ramjet fuel properties. O.C.

A86-49125#

PREDICTION OF SINGLE-ROTATION PROP-FAN NOISE BY A FREQUENCY DOMAIN SCHEME

H. GOUNET and S. LEWY (ONERA, Chatillon-sous-Bagneaux, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1442-1450. DRET-ONERA-supported research. refs (ONERA, TP NO. 1986-100)

The noise of single-rotating propfans is predicted from the solution of the Ffowcs-Williams and Hawkins equation in the frequency domain. The computations under the ICAO certification procedures are based on the concepts developed for conventional propellers, because the flying speeds are low. Emphasis is placed upon noise computation on the fuselage outer wall at cruise speed. Since the helical tip velocities are then transonic, the previous codes must be completed to take into account the non-compactness of the acoustic sources and the blade twist. In addition, a method of estimation of near-field propeller sound levels is developed from the Euler 3D equations. Finally, acoustic measurements on a 1 meter model propfan in the S1-MA transonic wind tunnel of Modane-Avrieux are presented and comparisons with theoretical results are given. Author

A86-49126#

CALCULATIONS OF HIGH SPEED PROPELLER PERFORMANCES USING FINITE DIFFERENCE METHODS

M. KOBAYAKAWA, H. ONUMA, and Y. SHIOTA (Kyoto University, Japan) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1451-1460. refs

In order to examine flowfield around an advanced turboprop by means of numerical calculations, finite difference methods are applied. The partial differential equation for the disturbance velocity potential is solved by the line-relaxation technique. Boundary fitted meshes are generated. The transformations between physical space and computational one are performed by a chain rule. The SR-3 propeller blade design is used for numerical calculations. In the second part, the Euler equations are solved by noniterative implicit ADI schemes in an AF algorithm. Boundary-fitted meshes are also used for this case. The results show qualitative agreement with the results by Bober et al. (1983). Finally, power coefficients and efficiencies are obtained. Potential calculations show that these quantities are larger than the experimental values obtained by NASA. Euler solutions, however, show that the values come closer to the experimental values. Author

A86-49611*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SMALL GAS TURBINE COMBUSTOR EXPERIMENTAL STUDY - COMPLIANT METAL/CERAMIC LINER AND PERFORMANCE EVALUATION

W. A. ACOSTA (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) and C. T. NORNGREN (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs (AIAA PAPER 86-1452)

Combustor research relating to the development of fuel efficient small gas turbine engines capable of meeting future commercial and military aviation needs is currently underway at NASA Lewis. As part of this combustor research, a basic reverse-flow combustor has been used to investigate advanced liner wall cooling techniques. Liner temperature, performance, and exhaust emissions of the experimental combustor utilizing compliant metal/ceramic liners were determined and compared with three previously reported combustors that featured: (1) splash film-cooled liner walls; (2) transpiration cooled liner walls; and (3) counter-flow film cooled panels. Author

A86-49614*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERSPECTIVES ON DILUTION JET MIXING

J. D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH) and R. SRINIVASAN (Garrett Turbine Engine Co., Phoenix, AZ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 31 p. refs (AIAA PAPER 86-1611)

A microcomputer code which displays 3-D oblique and 2-D plots of the temperature distribution downstream of jets mixing with a confined crossflow has been used to investigate the effects of varying the several independent flow and geometric parameters on the mixing. Temperature profiles calculated with this empirical model are presented to show the effects of orifice size and spacing, momentum flux ratio, density ratio, variable temperature mainstream, flow area convergence, orifice aspect ratio, and opposed and axially staged rows of jets. Author

A86-49620#

NONLINEAR DYNAMICS OR ROTOR/BLADE/CASING RUB INTERACTIONS

J. PADOVAN and F. K. CHOY (Akron, University, OH) ASME, Spring National Design Engineering Conference and Show, Chicago, IL, Mar. 24-27, 1986. 8 p. refs (ASME PAPER 86-DE-6)

This paper considers the transient analysis of rub problems in high speed rotating equipment which involve interactions between

the rotor, blades and casing. Special emphasis is given to ascertaining the participation characteristics of turbine/impeller blades during the overall rub event. To generalize the scope of the work, single and multiple blade rub events are considered including the effect of such system parameters as, imbalance magnitude, blade/rotor stiffness, system damping and rub interface friction characteristics.

Author

A86-50075

ADVANCED CONCEPTS IN SMALL HELICOPTER ENGINE AIR-COOLED TURBINE DESIGN

L. A. BEVILACQUA and W. E. LIGHTFOOT (General Electric Co., Aircraft Engine Business Group, Lynn, MA) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 2, no. 4, 1986, p. 327-335.

This paper reviews experience with advanced small engine turbine design, including application of proven large engine cooling technology to a new generation of small engines. The success in small engine advanced turbine design is exemplified by the T700/CT7 family of turboshaft engines. This family has accumulated over 300,000 hours of successful field operation. Design maturity, achieved by extensive factory testing prior to production introduction, has resulted in engine reliability substantially greater than other engines in its class. The potential impact on turbine design of new, short duration, one-engine-inoperative ratings are discussed.

Author

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SMALL GAS TURBINE COMBUSTOR EXPERIMENTAL STUDY: COMPLIANT METAL/CERAMIC LINER AND PERFORMANCE EVALUATION

W. A. ACOSTA (Army Aviation Research and Development Command, Cleveland, Ohio) and C. T. NORGREN 1986 16 p Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; sponsored by AIAA, ASME, SAE, and ASEE (NASA-TM-87304; E-3016; NAS 1.15:87304) Avail: NTIS HC A02/MF A01 CSCL 21E

Combustor research relating to the development of fuel efficient small gas turbine engines capable of meeting future commercial and military aviation needs is currently underway at NASA Lewis. As part of this combustor research, a basic reverse-flow combustor has been used to investigate advanced liner wall cooling techniques. Liner temperature, performance, and exhaust emissions of the experimental combustor utilizing compliant metal/ceramic liners were determined and compared with three previously reported combustors that featured: (1) splash film-cooled liner walls; (2) transpiration cooled liner walls; and (3) counter-flow film cooled panels.

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AEROPROPULSION OPPORTUNITIES FOR THE 21ST CENTURY

W. C. STRACK 1986 32 p Presented at the Scenario for 21st Century Aero Engine Design Seminar, Bristol, England, 16-17 May 1986; sponsored by the Institute of Mechanical Engineers (NASA-TM-88817; E-3177; NAS 1.15:88817) Avail: NTIS HC A03/MF A01 CSCL 21E

A large number of novel aeropropulsion system concepts are presented for subsonic through hypersonic applications offering large potential improvements. Collectively, these examples illustrate the revolutionary opportunities and challenges that could enable truly revolutionary aircraft capabilities in the future. Certainly not all of these concepts will ultimately prove fruitful. Nevertheless, the sheer number of existing concepts, including many unmentioned herein, is so large and the applications so vast, that the prognosis for the future of aeropropulsion is very encouraging indeed.

Author

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A PARAMETRIC STUDY OF A GAS-GENERATOR AIRTURBO RAMJET (ATR)

C. A. SNYDER 1986 19 p Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; sponsored by AIAA, ASME, SAE and ASEE (NASA-TM-88808; E-3156; NAS 1.15:88808) Avail: NTIS HC A02/MF A01 CSCL 21E

Parametric engine performance calculations were carried out for an airturbo ramjet (ATR). A LOX-LH2 rocket powered turbine powered the compressor. The engine was flown over a typical flight path up to Mach 5 to show the effect of engine off design operation. The compressor design efficiency, compressor pressure ratio, rocket turbine efficiency, rocket turbine inlet temperature, and rocket chamber pressure were varied to show their effect on engine net thrust and specific impulse at Mach 5 cruise. Estimates of engine weights as a function of the ratio of compressor air to rocket propellant flow and rocket chamber pressure are also included. In general, the Mach 5 results indicate that increasing the amount of rocket gas produced increased thrust but decreased the specific impulse. The engine performance was fairly sensitive to rocket chamber pressure, especially at higher compressor pressure ratios. At higher compressor pressure ratios, the engine thrust was sensitive to turbine inlet temperature. At all compressor pressure ratios, the engine performance was not sensitive to compressor or turbine efficiency.

Author

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AN OVERVIEW OF THE SMALL ENGINE COMPONENT TECHNOLOGY (SECT) STUDIES

M. R. VANCO, W. T. WINTUCKY, and R. W. NIEDZWIECKI Jun. 1986 20 p Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; cosponsored by AIAA, ASME, SAE, and ASEE (NASA-TM-88796; E-3131; NAS 1.15:88796; USAAVSCOM-TR-86-C-23; AIAA-86-1542) Avail: NTIS HC A02/MF A01 CSCL 21E

The objectives of the joint NASA/Army SECT Studies were to identify high payoff technologies for year 2000 small gas turbine engine applications and to provide a technology plan for guiding future research and technology efforts applicable to rotorcraft, commuter and general aviation aircraft and cruise missiles. Competitive contracts were awarded to Allison, AVCO Lycoming, Garrett, Teledyne CAE and Williams International. This paper presents an overview of the contractors' study efforts for the commuter, rotorcraft, cruise missile, and auxiliary power (APU) applications with engines in the 250 to 1,000 horsepower size range. Reference aircraft, missions and engines were selected. Advanced engine configurations and cycles with projected year 2000 component technologies were evaluated and compared with a reference engine selected by the contractor. For typical commuter and rotorcraft applications, fuel savings of 22 percent to 42 percent can be attained. For \$1/gallon and \$2/gallon fuel, reductions in direct operating cost range from 6 percent to 16 percent and from 11 percent to 17 percent respectively. For subsonic strategic cruise missile applications, fuel savings of 38 percent to 54 percent can be achieved which allows 35 percent to 60 percent increase in mission range and life cycle cost reductions of 40 percent to 56 percent. High payoff technologies have been identified for all applications.

Author

07 AIRCRAFT PROPULSION AND POWER

N86-31588*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TURBULENT DISPERSION OF THE ICING CLOUD FROM SPRAY NOZZLES USED IN ICING TUNNELS

C. J. MAREK and W. A. OLSEN, JR. May 1986 17 p Presented at the 3rd International Workshop on Atmospheric Icing of Structures, Vancouver, British Columbia, 6-8 May 1986 (NASA-TM-87316; E-3047; NAS 1.15:87316) Avail: NTIS HC A02/MF A01 CSCL 21E

To correctly simulate flight in natural icing conditions, the turbulence in an icing simulator must be as low as possible. But some turbulence is required to mix the droplets from the spray nozzles and achieve an icing cloud of uniform liquid water content. The goal for any spray system is to obtain the widest possible spray cloud with the lowest possible turbulence in the test section of a icing tunnel. This investigation reports the measurement of turbulence and the three-dimensional spread of the cloud from a single spray nozzle. The task was to determine how the air turbulence and cloud width are affected by spray bars of quite different drag coefficients, by changes in the turbulence upstream of the spray, the droplet size, and the atomizing air. An ice accretion grid, located 6.3 m downstream of the single spray nozzle, was used to measure cloud spread. Both the spray bar and the grid were located in the constant velocity test section. Three spray bar shapes were tested: the short blunt spray bar used in the NASA Lewis Icing Research Tunnel, a thin 14.6 cm chord airfoil, and a 53 cm chord NACA 0012 airfoil. At the low airspeed (56 km/hr) the ice accretion pattern was axisymmetric and was not affected by the shape of the spray bar. At the high airspeed (169 km/hr) the spread was 30 percent smaller than at the low airspeed. For the widest cloud the spray bars should be located as far upstream in the low velocity plenum of the icing tunnel. Good comparison is obtained between the cloud spread data and predictions from a two-dimensional cloud mixing computer code using the two equation turbulence (k epsilon g) model. Author

N86-31589# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

NEW TECHNOLOGY PROPULSION (ANT) FOR GENERAL AVIATION AIRCRAFT, PHASE 1 Final Report, Aug. 1985

I. BORCHERS, K. JONAS, R. MATECKI, H. KROJER, D. WELTE, and H. ZIMMER Bonn Bundesministerium fuer Forschung und Technologie Dec. 1985 158 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie (BMFT-FB-W-85-031; ISSN-0170-1339; ETN-86-97472) Avail: NTIS HC A08/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 32.50

The ANT concept for bimotor-turbopropelled aircraft developed from market-oriented requirements is characterized by two rear propellers and two engines installed inside the fuselage behind the passenger cabin, connected by transmission shafts. The concept is analyzed as regards aerodynamic quality, propeller installation efficiency, noise conditions and propeller load. The analysis is based on theoretical methods and wind tunnel tests with a 1:7 model. The propeller installation efficiency is improved by 10% to 14%. The specific range compared to that of an aircraft with conventional engine aircraft arrangement is increased by 15% and the maximum cruising speed by 7%. The noise level limit can be kept to 85 dB(A) and below. The dynamic behavior of the powerplant and noise should be further investigated. ESA

N86-32436# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

TURBISTAN: A STANDARD LOAD SEQUENCE FOR AIRCRAFT ENGINE DISKS

A. J. A. MOM, W. J. EVANS, and A. A. TENHAVE 19 Mar. 1985 15 p Presented at AGARD Structures and Materials Specialists' Meeting on Damage Tolerance Concepts for Critical Engine Components, San Antonio, Tex., Apr. 1985 (NLR-MP-85033-U; B8665117; ETN-86-97676) Avail: NTIS HC A02/MF A01

The development of TURBISTAN, an international loading standard representative for fighter engine disk usage is described. The compilation of operational flight data, their analysis, and the generation of a preliminary TURBISTAN sequence for cold compressor disks are outlined. The sequence contains 8000 cycles which represent 100 flights. A materials testing program to assess the effectiveness of the standard and to explore the validity of the assumptions made in its derivation is discussed. ESA

N86-32437# National Aerospace Lab., Amsterdam (Netherlands). Aerodynamics Div.

RECENT DEVELOPMENTS IN PROPULSION AERODYNAMICS

W. B. DEWOLF 29 Mar. 1985 13 p In DUTCH; ENGLISH summary Presented at the NVvL-VSV Symposium on Recent Developments in Aerodynamics, Delft, Netherlands, 26 Apr. 1986 (NLR-MP-85031-U; B8664743; ETN-86-97675) Avail: NTIS HC A02/MF A01

Developments in propulsion aerodynamics relevant to the aerodynamic design of civil aircraft are discussed. The striving for fuel economy resulted for turbofan engines in refinement of the nacelle configuration, including the exhaust nozzle system and the lowest possible interference drag. As a fuel saving alternative to the turbofan engine, the advanced propeller for cruise Mach numbers between 0.7 and 0.8 was investigated; fuel savings between 20% and 30% seem feasible. The conventional propeller was improved with respect to aerodynamics (blade airfoils), acoustics, and weight (composite materials). ESA

N86-32438# National Aerospace Lab., Amsterdam (Netherlands).

COST REDUCTIONS FROM INTRODUCTION OF NEW LIFE PHILOSOPHIES FOR AIRCRAFT ENGINE DISCS

A. J. A. MOM 23 Sep. 1985 17 p Presented at the 25th SAE Symposium E-32 Committee Meeting, Amsterdam, Netherlands, 21 Oct. 1985 (NLR-MP-85076-U; B8665116; ETN-86-97685) Avail: NTIS HC A02/MF A01

Turbine disk lifing procedures are discussed. The damage tolerance approach for disk lifing as well as a modified safe-life philosophy, the so-called refined cycle counting method, result in a considerable life extension in relation to the current safe-life approach. ESA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A86-47369

NEW METHODS FOR IN-FLIGHT VIBRATION TESTING [NOUVEAUX MOYENS D'ESSAIS DE VIBRATION EN VOL]

B. PENNACCHIONI (Centre d'Essais en Vol, Istres, France), R. DESTUYNDER, G. PIAZZOLI, and J.-F. BOISSEAU (ONERA, Chatillon-sous-Bagneux, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 110, 1985, p. 16-27. In French. refs

Several new devices and techniques are described for in-flight evaluation of new aircraft responses to various vibration modes. One goal of the new methods is to excite vibrations in a manner

which mimicks aerodynamic forces, thereby acquiring data for defining transfer functions for the aircraft responses. A second purpose is to identify the natural and damping modes of the aircraft structure, based on aerodynamic excitations which are impossible to induce on the ground. The methods can be used for both light aircraft and large transport aircraft. Features of pyrotechnic, electrical and hydraulic exciters are delineated, along with the placement of the exciters and accelerometers in the aircraft structure and in-flight applications procedures. Sample data are provided in terms of transfer functions relating vibratory forces with accelerations, maximum forces associated with discrete excitation frequencies, and vibratory coherence as a function of the symmetry or asymmetry of the excitations. M.S.K.

A86-47402#

THIRTY YEARS WITH THE JETS: COMMERCIAL TRANSPORT FLIGHT MANAGEMENT SYSTEMS - PAST, PRESENT, AND FUTURE

R. L. SCHOENMAN (Boeing Commercial Airplane Co., Seattle, WA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-10.

(AIAA PAPER 86-2289)

It has been almost thirty years since the first commercial jet transport entered airline service, and there have been many significant changes in flight-management systems during this period. A short historical review of these systems is presented for various time periods, followed by a discussion of the evolution of automatic-flight-control approaches and design techniques. This includes such areas as analysis, simulation, and laboratory and flight tests. The design of flight management systems for future aircraft is discussed, including such subjects as fly-by-wire, new display technology, flight-deck design, system integration, digital implementation of critical systems, etc. Finally, a discussion related to design issues and a view into the commercial transport environment of the future is offered. Author

A86-47416#

A STOCHASTIC DECENTRALIZED FLIGHT CONTROL SYSTEM

M. N. WAGDI (Suez Canal University, Port Fouad, Egypt) and A. A. KADER (Arab Organization for Industrialization, Cairo, Egypt) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 130-137.

(AIAA PAPER 86-1994)

A decentralized control method for stochastic systems is presented. More realistic and accurate stochastic representation for the system uncertainties is introduced. The major advantage of the present approach is its direct on-line implementation. A guide line for the choice of the subsystems structure is introduced. The effect of the coupling between the different subsystems is clarified. A subsystems interconnection controllability condition is defined. The stability of the decentralized control based on the present approach is addressed and stability criteria are developed. As an application to the present method a decentralized flight control system for a high performance fighter aircraft has been designed. The computational effort needed by the present decentralized flight control system is 40 percent of the required by using the standard centralized control approach. Comparison between the present decentralized control gains and those of standard centralized control is shown. Such comparison shows good agreement between the gains of the two control strategies. Author

A86-47419*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

AIRCRAFT CONTROL SURFACE FAILURE DETECTION AND ISOLATION USING THE OSGLR TEST

W. F. BONNICE, P. MOTYKA (Charles Stark Draper Laboratory, Inc., Cambridge, MA), E. WAGNER, and S. R. HALL (MIT, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 156-164. refs

(Contract NAS1-17556)

(AIAA PAPER 86-2028)

The performance of the orthogonal series generalized likelihood ratio (OSGLR) test in detecting and isolating commercial aircraft control surface and actuator failures is evaluated. A modification to incorporate age-weighting which significantly reduces the sensitivity of the algorithm to modeling errors is presented. The steady-state implementation of the algorithm based on a single linear model valid for a cruise flight condition is tested using a nonlinear aircraft simulation. A number of off-nominal no-failure flight conditions including maneuvers, nonzero flap deflections, different turbulence levels and steady winds were tested. Based on the no-failure decision functions produced by off-nominal flight conditions, the failure detection and isolation performance at the nominal flight condition was determined. The extension of the algorithm to a wider flight envelope by scheduling on dynamic pressure and flap deflection is examined. Based on this testing, the OSGLR algorithm should be capable of detecting control surface failures that would affect the safe operation of a commercial aircraft. Isolation may be difficult if there are several surfaces which produce similar effects on the aircraft. Extending the algorithm over the entire operating envelope of a commercial aircraft appears feasible. Author

A86-47421#

ROBUST FAULT DETECTION AND ISOLATION FOR A HIGH PERFORMANCE AIRCRAFT ON STOL APPROACH

M. E. BADGETT, R. A. WALKER (Integrated Systems, Inc., Palo Alto, CA), and K. R. HAIGES (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 180-189. Research supported by Northrop Corp. refs

(AIAA PAPER 86-2031)

Fault detection and isolation (FDI) techniques are becoming increasingly important components of robust, highly reconfigurable aircraft. In this paper, the theoretical and practical aspects of robust FDI design and implementation are discussed. Key issues involving error model realization, error model filtering, and error frequency shaping are addressed. The resulting techniques are utilized in the design of a FDI filter system for a high performance tactical aircraft on STOL approach. The results of simulated system failures show the clear superiority of robust FDI techniques presented here over conventional filtering techniques. Author

A86-47422*# Alphatech, Inc., Burlington, Mass.

SIMULATION RESULTS OF AUTOMATIC RESTRUCTURABLE FLIGHT CONTROL SYSTEM CONCEPTS

J. L. WEISS, D. P. LOOZE, J. S. ETERNO (Alphatech, Inc., Burlington, MA), and A. OSTROFF (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 190-197. refs

(Contract NAS1-17411)

(AIAA PAPER 86-2032)

The restructurable flight control system (RFCS) described by Weiss et al. (1986) is reviewed, and several results of an extensive six degrees of freedom nonlinear simulation of several aspects of this system are reported. It is concluded that the nontraditional use of standard control surfaces in a nominal feedback control system to spread control authority among many redundant control

elements provides a significant amount of fault tolerance without any use of restructuring techniques. The use of new feedback gains alone following a failure can provide significantly improved recovery as long as the control elements remain within their travel limits and as long as uncertainty about the failure identity is properly handled. The use of the feed-forward trim solution in conjunction with redesigned feedback gains allows recovery to take place even when significant control saturation occurs. C.D.

A86-47424*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF TOTAL ENERGY-RATE FEEDBACK FOR GLIDESCOPE TRACKING IN WIND SHEAR

C. M. BELCASTRO and A. J. OSTROFF (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 205-214. refs (AIAA PAPER 86-2035)

Low-altitude wind shear is recognized as an infrequent but significant hazard to all aircraft during take-off and landing. A total energy-rate sensor, which is potentially applicable to this problem, has been developed for measuring specific total energy-rate of an airplane with respect to the air mass. This paper presents control system designs, with and without energy-rate feedback, for the approach to landing of a transport airplane through severe wind shear and gusts to evaluate application of this sensor. A system model is developed which incorporates wind shear dynamics equations with the airplane equations of motion, thus allowing the control systems to be analyzed under various wind shears. The control systems are designed using optimal output feedback and are analyzed using frequency domain control theory techniques. Control system performance is evaluated using a complete nonlinear simulation of the airplane and a severe wind shear and gust data package. The analysis and simulation results indicate very similar stability and performance characteristics for the two designs. An implementation technique for distributing the velocity gains between airspeed and ground speed in the simulation is also presented, and this technique is shown to improve the performance characteristics of both designs. Author

A86-47425*# Rice Univ., Houston, Tex.
OPTIMIZATION AND ACCELERATION GUIDANCE OF FLIGHT TRAJECTORIES IN A WINDSHEAR

A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 215-236. Research supported by the Boeing Commercial Aircraft Co. refs (Contract NAG1-516) (AIAA PAPER 86-2036)

Guidance strategies for near-optimum performance in a wind shear are examined. The takeoff problem is considered with reference to flight in a vertical plane; the presence of a downdraft is assumed. Trajectories for optimum performance in a wind shear are determined for different wind shear models and intensities. Numerical experiments with the optimum control approach lead to the conclusion that, for weak to moderate shear/downdraft combinations, the optimal trajectory is characterized by a monotonic climb, and for severe shear/downdraft combinations, it is characterized by an initial climb, followed by a nearly horizontal flight, followed by renewed climbing after the aircraft has passed through the shear region. An acceleration guidance scheme based on relative acceleration is presented in both analytical form and feedback control form. Numerical results with this scheme result in trajectories close to the optimum and considerably superior to those arising from alternative guidance schemes. C.D.

A86-47437#

SENSITIVITY ANALYSIS OF HIGH-ORDER DIGITAL FLIGHT CONTROL SYSTEMS USING SINGULAR-VALUE CONCEPTS

J. D. PADUANO and D. R. DOWNING (Kansas, University, Lawrence) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 338-345. refs (AIAA PAPER 86-2084)

A recently developed sensitivity analysis technique for linear control systems, which is based on the gradients of the return-difference-matrix singular values, is improved by introducing system scaling, and extended to include digital systems. System scaling is used to improve the reliability of the singular values as measures of relative stability. Digital systems are included in the analysis through the derivation of new equations for the matrix singular value gradients. An example of the applicability of the method to high-order, digital, multiloop systems is presented using the X-29A lateral-directional control laws. Results for the X-29A are discussed, as well as the range of validity of these results. Author

A86-47442#

A THEORY FOR FAULT-TOLERANT FLIGHT CONTROL COMBINING EXPERT SYSTEM AND ANALYTICAL REDUNDANCY CONCEPTS

R. F. STENGEL (Princeton University, NJ) and D. A. HANDELMAN IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 375-384. refs (Contract DAAG29-84-K-0048) (AIAA PAPER 86-2092)

This paper presents a theory for rule-based fault-tolerant flight control. The objective is to define methods for designing control systems capable of accommodating a wide range of aircraft failures, including sensor, control, and structural failures. A software architecture is described that integrates quantitative analytical redundancy techniques and heuristic expert system concepts for the purpose of in-flight, real-time fault tolerance. The resultant controller uses a rule-based expert system approach to transform the problem of failure accommodation task scheduling and selection into a problem of search. Control system performance under sensor and control failures is demonstrated using linear discrete-time deterministic simulations of a tandem-rotor helicopter's dynamics. It is found that the rule-based control theory can be used to enhance existing redundancy management systems. This approach to control system design also provides inherent parallelism for computational speed, smooth integration of algorithmic and heuristic computation, a search-based decision-making mechanism, straightforward system organization and debugging, and an incremental growth capability. Author

A86-47455*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DESIGN FACTORS AND CONSIDERATIONS FOR A TIME-BASED FLIGHT MANAGEMENT SYSTEM

D. D. VICROY, D. H. WILLIAMS (NASA, Langley Research Center, Hampton, VA), and J. A. SORENSEN (Seagull Technology, Inc., Sunnyvale, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 493-497. (AIAA PAPER 86-2144)

Recent NASA Langley Research Center research to develop a technology data base from which an advanced Flight Management System (FMS) design might evolve is reviewed. In particular, the generation of fixed range cruise/descent reference trajectories which meet predefined end conditions of altitude, speed, and time is addressed. Results on the design and theoretical basis of the trajectory generation algorithm are presented, followed by a brief discussion of a series of studies that are being conducted to determine the accuracy requirements of the aircraft and weather

models resident in the trajectory generation algorithm. Finally, studies to investigate the interface requirements between the pilot and an advanced FMS are considered. C.D.

A86-47456# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ROTARY-WING AIRCRAFT TERRAIN-FOLLOWING/TERRAIN-AVOIDANCE SYSTEM DEVELOPMENT

D. W. DORR (NASA, Ames Research Center, Moffett Field, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 498-504. refs (AIAA PAPER 86-2147)

Work being accomplished to develop a real-time, piloted simulation of a helicopter using the vertical motion simulator at NASA Ames is discussed. The trajectory generation algorithm and the flight path controller are described, and the software integration of the entire terrain following/terrain avoidance (TF/TA) system is discussed. Real-time simulation requirements and the unique features of applying TF/TA system to helicopter flight are summarized. Initial results indicate that the system is satisfactory for automatic, low level TF/TA helicopter flight. C.D.

A86-47464# SYNTHESIS OF AN ADAPTIVE FLIGHT CONTROLLER UNDER UNKNOWN DETERMINISTIC DISTURBANCES

K. KANAI, S. UCHIKADO (National Defense Academy, Yokosuka, Japan), P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada), and N. HORI IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 565-572. refs (AIAA PAPER 86-2157)

Two methods of designing an adaptive flight control system are developed using an algebraic polynomial method. The first is based on the direct control method which identifies the plant parameters implicitly and the second on the indirect method which does explicitly. The controllers which are designed using these schemes are able to take account of the uncertainties in the aircraft's control and stability derivatives and are robust to the deterministic disturbances. Their application to the flight control of small, high-performance aircraft is examined using numerical simulations which show that the proposed schemes are effective. Author

A86-47465# AN EXPLICIT ADAPTIVE FLIGHT CONTROL SYSTEM BASED ON THE MODIFIED GAIN EXTENDED KALMAN FILTER

J. L. SPEYER, Z. CRUES, and W.-P. FUN (Texas, University, Austin) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 573-580. Research sponsored by General Dynamics Corp. refs (Contract AF-AFOSR-84-0371) (AIAA PAPER 86-2158)

A new explicit adaptive control scheme for the flight control system of a modern aircraft is developed. This scheme is based upon using a tailored filter structure for state and parameter estimation called the modified gain extended Kalman filter (MGEKF) which is placed in cascade with a controller. The adaptive controller gain is inversely proportional to M_e , the moment coefficient with respect to elevator deflection keeping angle-of-attack and pitch rate constant. It is shown in a linear simulation that M_e is very well estimated by the MGEKF when faced with large changes in flight conditions, in the presence of different levels of clear air turbulence, and different instrument quality while using reasonably low level of dither. Furthermore, one of the conclusions of this study is that the gain could be inversely proportional to H_e , the moment coefficient with respect to elevator deflection keeping acceleration and pitch rate constant, since H_e is also estimated very well. Author

A86-47475#

A DESIGN METHODOLOGY FOR ROBUST STABILIZING CONTROLLERS

W. E. SCHMITENDORF (Northwestern University, Evanston, IL) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 657-662. refs (Contract NSF ECS-84-15591; AF-AFOSR-ISSA-85-00051) (AIAA PAPER 86-2195)

This paper considers the problem of designing control laws for linear systems with time-varying uncertainty. A method for determining a linear feedback control which stabilizes the system for all possible uncertainty is presented. This control is robust in the sense that it guarantees asymptotic stability regardless of the disturbance. The results are applied to several aircraft examples. Author

A86-47481#

PITCH RATE SENSITIVITY CRITERION FOR CATEGORY C FLIGHT PHASES - CLASS IV AIRCRAFT

S. R. STURMER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 703-710. refs (AIAA PAPER 86-2201)

A criterion for selecting high-frequency gain of the transfer function in category C flight phases in class IV aircraft is proposed which uses the aircraft's pitch rate frequency response to plot amplitude ratios versus phase angles. The available data indicate that the desired pitch rate sensitivity for a range of response dynamics results in a relatively constant amplitude-phase plot. This result seems consistent even with degraded response dynamics such as increased time delay. The criterion is thus useful not only for the design process but also for the development of flying qualities evaluation. C.D.

A86-47482# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

EFFECT OF TIME DELAY ON FLYING QUALITIES - AN UPDATE

R. E. SMITH (NASA, Flight Research Center, Edwards, CA) and S. K. SARAFIAN IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 711-720. refs (AIAA PAPER 86-2202)

Flying qualities problems of modern, full-authority electronic flight control systems are most often related to the introduction of additional time delay in aircraft response to a pilot input. These delays can have a significant effect on the flying qualities of the aircraft. This paper reexamines time delay effects in light of recent flight test experience with aircraft incorporating new technology. Data from the X-29A forward-swept-wing demonstrator, a related preliminary in-flight experiment, and other flight observations are presented. These data suggest that the present MIL-F-8785C allowable-control system time delay specifications are inadequate or, at least, incomplete. Allowable time delay appears to be a function of the shape of the aircraft response following the initial delay. The cockpit feel system is discussed as a dynamic element in the flight control system. Data presented indicate that the time delay associated with a significant low-frequency feel system does not result in the predicted degradation in aircraft flying qualities. The impact of the feel system is discussed from two viewpoints: as a filter in the control system which can alter the initial response shape and, therefore, the allowable time delay, and as a unique dynamic element whose delay contribution can potentially be discounted by special pilot loop closures. Author

A86-47483#

LIMITATIONS OF STATICALLY UNSTABLE AIRCRAFT DUE TO THE EFFECTS OF SENSOR NOISE, TURBULENCE, AND STRUCTURAL DYNAMICS

H. BEAUFRERE (Grumman Corp., Bethpage, NY) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 721-731.

(Contract F33615-84-C-3604)

(AIAA PAPER 86-2203)

Control system design guidelines for statically unstable aircraft are extended from previous work to include the effects of sensor noise, turbulence, and structural dynamics. Classical frequency domain techniques are used that avoid complex computer codes. Simple closed-form algebraic expressions are obtained that parametrically define the impact these effects have on control system design requirements and constraints. These effects are shown to limit the amount of static instability a configuration can have, and to have a decided influence on aircraft agility factors related to dynamic pitch response and high-alpha controllability.

Author

A86-47488#

CONTROL RECONFIGURABLE COMBAT AIRCRAFT FLIGHT CONTROL SYSTEM DEVELOPMENT

W. WEINSTEIN (Grumman Corp., Aircraft Systems Div., Bethpage, NY), W. POSINGIES (Honeywell Inc., Avionics Div., Saint Louis Park, MN), R. A. ESLINGER, and H. N. GROSS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 772-783. refs (AIAA PAPER 86-2236)

The results are reported of an ongoing study that exploits the concepts of graceful degradation and reconfiguration to improve the reliability and maintainability (R&M), lower the life cycle costs, and decrease the vulnerability of the flight control systems (FCS) for a conceptual advanced fighter aircraft. These results are achieved by eliminating the criticality of each control effector, reducing the number of effectors, making more efficient use of existing effectors, lowering hardware redundancy levels of processors and sensors, and simplifying the actuators. The baseline aircraft configuration is described, some effector deployments are listed, and configuration strategies that were investigated to improve graceful degradation are stated. The Control Reconfigurable Combat Aircraft effector configuration and the remaining FCS architecture are developed, and the analysis of the quantitative value of the reconfiguration is documented.

C.D.

A86-47489*# National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.

FLIGHT CONTROL SYSTEM DEVELOPMENT AND FLIGHT TEST EXPERIENCE WITH THE F-111 MISSION ADAPTIVE WING AIRCRAFT

R. R. LARSON (NASA, Flight Research Center, Edwards, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 784-801. refs (AIAA PAPER 86-2237)

The wing on the NASA F-111 transonic aircraft technology airplane was modified to provide flexible leading and trailing edge flaps. This wing is known as the mission adaptive wing (MAW) because aerodynamic efficiency can be maintained at all speeds. Unlike a conventional wing, the MAW has no spoilers, external flap hinges, or fairings to break the smooth contour. The leading edge flaps and three-segment trailing edge flaps are controlled by a redundant fly-by-wire control system that features a dual digital primary system architecture providing roll and symmetric commands to the MAW control surfaces. A segregated analog backup system is provided in the event of a primary system failure. This paper discusses the design, development, testing, qualification, and flight test experience of the MAW primary and backup flight control systems.

Author

A86-47490#

DESIGN OF AN INTEGRATED CONTROL SYSTEM FOR FLUTTER MARGIN AUGMENTATION AND GUST LOAD ALLEVIATION, TESTED ON A DYNAMIC WINDTUNNEL MODEL

P. A. VAN GELDER (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 802-811. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart en Nationaal Lucht- en Ruimtevaartlaboratorium. refs (AIAA PAPER 86-2242)

An integrated design for a control system for both gust load alleviation and flutter margin augmentation is described. The control law design is discussed in detail, including the mathematical model, the choice of weighting matrices for the aileron control law, and the spoiler control law. The wind tunnel testing of a design process for a reduced-order output controller is reported. The results show that gust loads can be reduced by 50 percent while simultaneously creating a flutter speed margin extending 20 percent beyond the unaugmented flutter speed.

C.D.

A86-47491*# University of Western Michigan, Kalamazoo.

EIGENSYSTEM SYNTHESIS FOR ACTIVE FLUTTER SUPPRESSION ON AN OBLIQUE-WING AIRCRAFT

G. S. ALAG (Western Michigan University, Kalamazoo, MI), J. J. BURKEN, and G. B. GILYARD (NASA, Flight Research Center, Edwards, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 812-817. refs (AIAA PAPER 86-2243)

The application of the eigensystem synthesis technique to place the closed-loop eigenvalues and shape the closed-loop eigenvectors has not been practical for active flutter suppression, primarily because of the availability of only one control surface (aileron) for flutter suppression. The oblique-wing aircraft, because of its configuration, provides two independent surfaces (left and right ailerons), making the application of eigensystem synthesis practical. This paper presents the application of eigensystem synthesis using output feedback for the design of an active flutter suppression system for an oblique-wing aircraft. The results obtained are compared with those obtained by linear quadratic Gaussian techniques.

Author

A86-47492*# University of Western Michigan, Kalamazoo.

MODEL-FOLLOWING CONTROL FOR AN OBLIQUE-WING AIRCRAFT

G. S. ALAG (Western Michigan University, Kalamazoo, MI), R. W. KEMPEL, J. W. PAHLE, J. J. BRESINA, and F. BARTOLI (NASA, Flight Research Center, Edwards, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 818-827. refs (AIAA PAPER 86-2244)

A variable-skew oblique wing offers a substantial aerodynamic performance advantage for aircraft missions that require both high efficiency in subsonic flight and supersonic dash or cruise. The most obvious characteristic of the oblique-wing concept is the asymmetry associated with wing-skew angle which results in significant aerodynamic and inertial cross-coupling between the aircraft longitudinal and lateral-directional axes. This paper presents a technique for synthesizing a decoupling controller while providing the desired stability augmentation. The proposed synthesis procedure uses the concept of explicit model following. Linear quadratic optimization techniques are used to design the linear feedback system. The effectiveness of the control laws developed in achieving the desired decoupling is illustrated for a given flight condition by application to linearized equations of motion, and also to the nonlinear equations of six degrees of freedom of motion with nonlinear aerodynamic data.

Author

A86-47493#

APPLICATION OF EIGENSTRUCTURE ASSIGNMENT TO DESIGN OF ROBUST DECOUPLING CONTROLLERS IN MIMO SYSTEMS

V. F. GAVITO (U.S. Navy, Washington, DC) and D. J. COLLINS (U.S. Naval Postgraduate School, Monterey, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 828-834. refs (AIAA PAPER 86-2246)

Numerical optimization techniques have been used to develop an interactive algorithm which allows the full specification of a set of closed loop eigenvalues and the allowable elements of the corresponding closed loop eigenvector matrix. The algorithm can be implemented in a manner that insures robustness. Both state variable and output feedback controllers can be readily designed. The algorithm is first applied to decouple the lateral dynamics of the CH-47 helicopter, the resulting controller is shown to give rise to a robust closed loop system which meets performance requirements to step response in roll input. Robustness measures and transient response performance of this decoupling controller are compared with three other CH-47 control law designs. A robust output feedback controller which decouples the lateral dynamics of the L-1011 commercial transport is then designed by use of the algorithm. Resulting performance measures and transient responses are compared with published results. It is shown that these decoupling controllers offer a direct guarantee of a robust closed loop system by minimizing the coupling elements of the respective eigenvector matrices. The robustness of each of the decoupled designs is further increased by a second application of the design algorithm in which the eigensystem structure is assigned while at the same time placing a constraint on the minimum singular value of the return difference matrix. Author

A86-47494*# Minnesota Univ., Minneapolis.

DESIGN OF A MULTIVARIABLE FLUTTER CONTROL/GUST LOAD ALLEVIATION SYSTEM

B. S. LIEBST, W. L. GARRARD, and J. A. FARM (Minnesota, University, Minneapolis) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 835-847. Research supported by the University of Minnesota. refs (Contract NAG1-217; NSF DMS-84-13129) (AIAA PAPER 86-2247)

This paper discusses the use of eigenspace techniques for the design of an active flutter control/gust load alleviation system for a hypothetical research drone. One leading edge and two trailing edge aerodynamic surfaces are available for control. Full state control laws are designed for two combinations of control surfaces by selecting feedback gains which place closed loop eigenvalues and shape closed loop eigenvectors so as to stabilize wing flutter and reduce gust loads at the wing root while yielding acceptable robustness and satisfying constraints on rms control surface activity. These controllers are realized by state estimators designed using an eigenvalue placement/eigenvector shaping technique which results in recovery of the loop transfer characteristics of the full state feedback systems. The resulting feedback compensators are shown to perform almost as well as the full state designs. They also exhibit acceptable performance in situations in which the failure of an actuator is simulated. Author

A86-47495*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ADAPTIVE FILTERING OF BIODYNAMIC STICK FEEDTHROUGH IN MANIPULATION TASKS ON BOARD MOVING PLATFORMS

M. VELGER (NASA, Ames Research Center, Moffett Field, CA; Technion Israel Institute of Technology, Haifa, Israel), A. GRUNWALD, and S. MERHAV (Technion Israel Institute of Technology, Haifa, Israel) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 848-858. refs (Contract F33615-82-C-0520) (AIAA PAPER 86-2248)

A novel approach to suppress the effects of biodynamic interference is presented. An adaptive noise canceling technique is employed for subtracting the platform motion correlated components from the control stick output. The effects of biodynamic interference and its suppression by adaptive noise cancellation has been evaluated in a series of tracking tasks performed in a moving base simulator. Simulator motions were in pitch, roll and combined pitch and roll. Human operator performance was assessed from the mean square values of the tracking error and the control activity. The tracking error and the total stick output signal were found to increase significantly with motion and to diminish substantially with adaptive noise cancellation, thus providing a considerable improvement in tracking performance under conditions in which platform motion were present. The adaptive filter was found to cause a significant increase in the cross-over frequency and decrease in the phase margin. Moreover, the adaptive filter was found to significantly improve the human operator visual motor response. This improvement is manifested as an increased human operator gain, a smaller time delay and lower pilot workload. Author

A86-47496#

IDENTIFICATION OF PILOT DYNAMICS IN A SYSTEM WITH A CHOICE OF FEEDBACK STRUCTURES

N. GOTO (Kyushu University, Fukuoka, Japan) and T. MATSUO IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 859-866. refs (AIAA PAPER 86-2250)

In altitude control of aircraft the pilot has a choice of feedback structures: either he closes a lead equalized altitude feedback single loop, or he constitutes a pitch attitude control inner loop. Taking this example, the paper proposes a method by which it is possible to choose the feedback structure actually employed by the pilot, and to identify the pilot dynamics in the system with an inner loop. Identification is done by using the autoregressive scheme, and determining a proper feedback structure is done by examining the correlation of the innovation processes as well as the identified dynamics. Based on a credibility study, the method is applied in this work to simulator and flight test data. It is shown that the pilot preferably closes a pitch attitude control inner loop, though a run-to-run variability is exhibited, depending on the pilot. When the feedback structure with a pitch attitude inner loop is employed, it is observed that the often assumed high gain characteristics in the inner loop are limited. Author

A86-47497#

TERMINAL CONTROL FACTORS FOR THE CARRIER LANDING TASK

R. K. HEFFLEY (Manudyn Systems, Inc., Los Altos, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 867-874. refs (AIAA PAPER 86-2251)

The problem of ensuring good controllability of glideslope, airspeed, and lineup is considered for Navy carrier aircraft. Analysis of outer-loop control of glideslope and airspeed indicates that the crucial parameters for control within limited time or space are effective airspeed lag from airframe and thrust lag for airspeed and effective glideslope lag from airframe for glideslope. A

fixed-base simulator experiment was used to confirm this hypothesis and to establish pilot workload sensitivities. It was found that when these parameters are varied independently, each strongly affects successful completion of the final approach task for a carrier landing. Furthermore, these key parameters are important to the preliminary design because they are set by basic planform, wing loading, and engine characteristics and are therefore difficult to modify at a later stage. Finally, it is recommended that flying qualities specifications and standards specifically address these characteristics and ensure that requirements for inner-loop control are compatible.

Author

A86-47509#

FLIGHT TEST EVALUATION OF TECHNIQUES TO PREDICT LONGITUDINAL PILOT INDUCED OSCILLATIONS

E. A. BJORKMAN, J. T. SILVERTHORN (USAF, Test Pilot School, Edwards, CA), and R. A. CALICO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 967-975. refs (AIAA PAPER 86-2253)

This paper presents the results of a study to determine if pilot induced oscillations (PIOs) can be predicted prior to flight using existing techniques. Two proposed analytical techniques to predict longitudinal PIO tendencies were applied to 18 aircraft/flight control system (FCS) configurations in the landing phase. Predictions were made concerning PIO rating and frequency. The 18 configurations were then flight tested using the USAF/Calspan variable stability NT-33. Actual PIO ratings and frequencies were compared to those predicted by each technique. PIO frequencies were correctly predicted within an average of 13 percent, and PIO ratings were predicted within an average of 0.6 PIO rating. Changes to both techniques were proposed to improve their ability to predict PIO tendency and to provide for PIO rating prediction.

Author

A86-47516*# Boeing Commercial Airplane Co., Seattle, Wash. NASA B737 FLIGHT TEST RESULTS OF THE TOTAL ENERGY CONTROL SYSTEM

K. R. BRUCE (Boeing Commercial Airplane Co., Seattle, WA), J. R. KELLY, and L. H. PERSON, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 10 p. (AIAA PAPER 86-2143)

The Total Energy Control System was developed and tested in September 1985 during five flights on the NASA Langley Transport System Research Vehicle, a modified Boeing B737. In the system, the total kinetic and potential energy of the aircraft is controlled by the throttles, and the energy distribution is controlled by the elevator. A common inner loop is used for each mode of the autopilot, and all the control functions of a conventional pitch autopilot and autothrottle are integrated into a single generalized control concept, providing decoupled flightpath and maneuver control, and a coordinated throttle response for all maneuvers. No instabilities or design problems requiring gain adjustment in flight were found, and comparison with simulation results showed excellent path tracking.

R.R.

A86-47523*# Calspan Corp., Buffalo, N. Y. THE INTERPRETATION OF FLYING QUALITIES REQUIREMENTS FOR FLIGHT CONTROL DESIGN

E. G. RYNASKI, N. C. WEINGARTEN (Calspan Corp., Buffalo, NY), and W. GRANTHAM (NASA, Langley Research Center, Hampton, VA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 9 p. refs (AIAA PAPER 86-2249)

The flying requirements of MIL-F-8785(C) are interpreted in terms of command/response configurations, and pilot preference for flight control systems configurations of angle of attack, or pitch rate command, specified independently for the short period and phugoid dynamics, is determined using the Total-In-Flight-Simulator aircraft. The results show that for either command configuration, the short term response applies to the angle of attack response

of the vehicle, and that this response must satisfy the $\omega(n)$ vs n/α requirement. The preference in the long term for angle of attack command indicates that the pilot wants the aircraft to fly in the direction it is pointing, and an attitude hold system is not found to be preferred unless attitude hold results in flight path angle hold.

R.R.

A86-47651

ATMOSPHERIC FLIGHT MECHANICS CONFERENCE, WILLIAMSBURG, VA, AUGUST 18-20, 1986, TECHNICAL PAPERS

Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 546 p. For individual items see A86-47652 to A86-47705.

The present conference considers a robust adaptive flightpath reconstruction technique, the application of parameter estimation to highly unstable aircraft, dynamical path optimization of aerospace vehicles, the use of flight simulation to develop terminal instrument procedures for transport category aircraft, the flight dynamics of aeroelastic vehicles, optimal missile range with respect to thrust and altitude profiles, the attenuation of Magnus effect on a missile with N-vanes, the effects of heave damping on helicopter handling qualities, and an optimal descending hypersonic turn-to-heading. Also discussed are an unsteady low speed aerodynamic model for complete aircraft configurations, a dynamic model for the real time estimation of aerodynamic characteristics, the aerodynamics of delta wings with leading edge blowing, an analysis of airline flight records for winds and performance with reference to the Delta 191 accident, the use of hinged strakes for lateral control at high angles-of-attack, vortex-induced effects on aircraft dynamics, the spherical mapping and analysis of aircraft angles for maneuvering flight, and a concept of automated aircraft guidance for air-to-air missions.

O.C.

A86-47652#

RECURSIVE REAL-TIME IDENTIFICATION OF STEP-RESPONSE MATRICES OF HIGH-PERFORMANCE AIRCRAFT FOR ADAPTIVE DIGITAL FLIGHT CONTROL

B. PORTER and A. MANGANAS (Salford, University, England) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-6. refs (Contract AF-AFOSR-85-0208) (AIAA PAPER 86-2017)

It is shown that, by incorporating fast on-line recursive identifiers to provide updated step-resonance matrices for inclusion in digital PID control laws, highly effective adaptive digital set-point tracking controllers can be readily designed for multivariable plants. The effectiveness of such an adaptive controller is illustrated by the design of an adaptive direct digital flight-mode control system for the X-29 aircraft.

Author

A86-47653*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A ROBUST ADAPTIVE FLIGHTPATH RECONSTRUCTION TECHNIQUE

M. H. VERHAEGEN (NASA, Ames Research Center, Moffett Field, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 7-19. refs (AIAA PAPER 80-2018)

Computational schemes are presented that allow accurate reconstruction of an aircraft's flightpath in real-time. The reconstruction of the flightpath is formulated as a linear state reconstruction problem, which can be solved via Kalman filtering (KF) techniques. This imposes some conditions upon the flight-test equipment. A reliable square root covariance KF (SRKF) implementation is chosen and further developed into a fully adaptive flightpath reconstruction scheme. Therefore, the basic SRKF is modified in order to cope with several practical problems such as: the automatic control of the convergence of the recursive KF calculations, time varying zero-bias errors on the input signal of the system model used in the KF, and the changing aircraft

dynamics owing to a change in reference flight condition. The developed solutions for these problems are all implemented in a numerically stable way, which guarantees the overall flightpath reconstruction scheme to be robust. Furthermore, some special features of the used system model are exploited to make the algorithmic implementation very efficient. An experimental simulation study using simulated flight test data demonstrated these different capabilities. Author

A86-47654*# Integrated Systems, Inc., Palo Alto, Calif.
REAL-TIME FLUTTER IDENTIFICATION WITH CLOSE MODE RESOLUTION

R. H. ROY, R. A. WALKER (Integrated Systems, Inc., Palo Alto, CA), and G. B. GILYARD (NASA, Flight Research Center, Edwards, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 20-24. refs (AIAA PAPER 86-2019)

Real-time flutter prediction including close modes can be effectively estimated from turbulence or on-board excitation with an Extended Kalman Filter (EKF) approach. A physically based model form enables prediction of the damping rate as well as damping, giving a time to instability estimate with its variance. The approach is recursive and can operate asynchronously to drop data outliers and hence is quite robust. Its speed is reasonable for on-line application but can also be used effectively as an off-line analysis tool for application to any modal testing situation. Author

A86-47655*# National Aeronautics and Space Administration.
Flight Research Center, Edwards, Calif.
APPLICATION OF PARAMETER ESTIMATION TO HIGHLY UNSTABLE AIRCRAFT

R. E. MAINE and J. E. MURRAY (NASA, Flight Research Center, Edwards, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 25-36. refs (AIAA PAPER 86-2020)

This paper discusses the application of parameter estimation to highly unstable aircraft. It includes a discussion of the problems in applying the output error method to such aircraft and demonstrates that the filter error method eliminates these problems. The paper shows that the maximum likelihood estimator with no process noise does not reduce to the output error method when the system is unstable. It also proposes and demonstrates an ad hoc method that is similar in form to the filter error method, but applicable to nonlinear problems. Flight data from the X-29 forward-swept-wing demonstrator is used to illustrate the problems and methods discussed. Author

A86-47660#
PRESSURE MEASUREMENTS IN A LIQUID-FILLED CYLINDER USING A THREE-DEGREE-OF-FREEDOM FLIGHT SIMULATOR
 D. J. HEPNER, T. M. KENDALL, B. S. DAVIS, and W. Y. TENLY (U.S. Army, Ballistics Research Laboratories, Aberdeen Proving Ground, MD) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 62-68. refs (AIAA PAPER 86-2026)

A three degree-of-freedom flight simulator was used to simulate the angular motion of a spin-stabilized projectile in order to measure internal pressures on a liquid-filled cylinder. Theory and experiments for the flight stability of liquid-filled shell are often based upon linearized theory and tests of subscale models. This simulator is sufficiently large to produce full scale tests and allows for the location of a large number and type of transducers. Pressure and accelerometer measurements were taken and recorded in a continuous fashion on an endwall and the sidewall of a cylinder with an internal Reynolds number of 18,200. Tests at several different amplitudes of yaw allowed for comparisons with a linear theory. Nonlinear trends were observed. Measurements of the

phase difference between the pressure and the yawing motion are presented. Pressure data are available for prograde and retrograde yawing motion, and they provide a new verification of the theory for a very wide range of the coning frequency. Author

A86-47661#
PARAMETRIC STUDY OF LOW REYNOLDS NUMBER PRECESSING/SPINNING INCOMPRESSIBLE FLOWS

M. J. NUSCA and W. P. DAMICO, JR. (U.S. Army, Ballistics Research Laboratories, Aberdeen Proving Ground, MD) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 69-77. refs (AIAA PAPER 86-2027)

Three-dimensional, steady state, laminar, fully viscous Navier-Stokes simulations were used to predict the behavior of incompressible liquids that were undergoing steady spin and steady precession at a fixed precession angle. These numerical simulations can predict steady viscous and pressure moments. These moments tend to increase the precession angle and reduce the spin rate of the container system. For a completely filled cylinder, liquid-induced roll and yaw moments were computed as functions of cylinder height to diameter ratios between 1 and 5.2, Reynolds number of between 5 and 45, ratio of precession to spin rate 0.5 to 0.1, and precession angle of less than 20. Comparisons were obtained between two codes and experimental data (spin fixture, free gyroscope, and yawsonde-instrumented projectile flights). Author

A86-47665#
TURBULENCE RESPONSE MATCHING IN THE NT-33A IN-FLIGHT SIMULATOR

L. H. KNOTTS and J. E. PRIEST (Calspan Corp., Buffalo, NY) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 111-119. refs (Contract F33615-83-C-3603) (AIAA PAPER 86-2076)

A recent NT-33A in-flight simulation program was conducted to evaluate the flying qualities of a highly augmented modern fighter aircraft during the approach and landing piloting task. One of the observations of the early flight evaluations was that the aircraft's flying qualities degraded significantly in the presence of atmospheric turbulence. A subsequent analytical investigation concluded that much of this turbulence effect could be attributed to the very high angle of attack and sideslip gains needed by the NT-33A variable stability system to produce the desired dynamics for the simulated unaugmented airframe. These feedback quantities were provided by vane sensors. To reduce the effect of atmospheric turbulence on the in-flight simulation, an air data system containing angle of attack and sideslip complementary filters was designed and installed in the NT-33A. The filters blend inertially calculated information with vane information to provide a smooth signal without introducing phase lag. In addition to providing gust free angle of attack and sideslip signals for use in the feedback control system, the air data system provides measured gust quantities which can be introduced into the variable stability system to produce the desired turbulence response. By proper selection of feedback gains on the gust terms, the turbulence response of a simulated aircraft can be matched independent of its response to a pilot command. Flight test in the NT-33A following implementation of the air data system showed that the effect of turbulence on the in-flight simulation was significantly reduced. Author

A86-47666*# Purdue Univ., West Lafayette, Ind.
ON THE FLIGHT DYNAMICS OF AEROELASTIC VEHICLES
 D. K. SCHMIDT (Purdue University, West Lafayette, IN) and M. R. WASZAK IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 120-133. refs
 (Contract NAG1-254)
 (AIAA PAPER 86-2077)

The nonlinear equations of motion for an elastic airplane are developed from first principles. Lagrange's Equation and the Principle of Virtual Work are used to generate the equations of motion and strip theory is then employed to obtain closed form integral expressions for the generalized forces. The inertial coupling is minimized by appropriate choice of the body reference axes and by making use of free vibration modes of the body. In addition, particular attention is paid to the simplifying assumptions used during the development of the equations of motion. A unique aspect of this modeling process is that since the generalized aerodynamic forces are determined from closed form, analytic expressions, this method can be used to gain insight into the effects of parameter variations not easily obtained from numerical models. A numerical example is also presented in which the modeling method is applied to a representative elastic aircraft. The model is used to address the effects of aerodynamic coupling which occurs between the rigid body degrees of freedom and the elastic degrees of freedom. Finally, model simplification is addressed and two methods are evaluated. The resulting frequency responses are compared.

Author

A86-47672*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

VALIDATION OF A NEW FLYING QUALITY CRITERION FOR THE LANDING TASK

D. T. BERRY and S. K. SARAFIAN (NASA, Flight Research Center, Edwards, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 175-181. Previously announced in STAR as N86-26341. refs
 (AIAA PAPER 86-2126)

A strong correlation has been found to exist between flight path angle peak overshoot and pilot ratings for the landing task. The use of flight path overshoot as a flying quality metric for landing is validated by correlation with four different in-flight simulation programs and a ground simulation study. Configurations tested were primarily medium-weight generic transports. As a result of good correlation with this extensive data base, criterion boundaries are proposed for landing based on the flight path peak overshoot metric.

Author

A86-47674#

A FUNDAMENTAL APPROACH TO EQUIVALENT SYSTEMS ANALYSIS

D. K. SCHMIDT (Purdue University, West Lafayette, IN) and B. J. BACON IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 193-205. refs
 (Contract N62269-83-C-0220)
 (AIAA PAPER 86-2128)

The use of low-order approximations, equivalent systems, in evaluating aircraft handling qualities is reviewed. Critical characteristics that must be reflected in the approximation, as well as factors influencing the likelihood of obtaining the appropriate low-order approximation are discussed. An alternate procedure is offered that extends the current approach to the evaluation of more complex, multi-loop piloted tasks.

Author

A86-47675#

THE EFFECT OF HEAVE DAMPING (ZW) ON HELICOPTER HANDLING QUALITIES

S. BAILLIE (National Aeronautical Establishment, Flight Research Laboratory, Ottawa, Canada) and R. HOH (Systems Technology, Inc., Hawthorne, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 206-213. refs
 (AIAA PAPER 86-2129)

A program investigating the effect of changes in heave damping (Zw) on helicopter handling qualities is described. Using the Canadian National Aeronautical Establishment Bell 205 Airborne Simulator, two advanced control system models were evaluated with differing levels of Zw. The control systems were Attitude Command/Attitude Hold and Rate Command/Attitude Hold systems with turn-coordination and heading hold. The evaluation results indicate that the proposed 8501 Zw hover envelope for Level 1 aircraft is conservative when coupled with these advanced control systems in other aircraft axes.

Author

A86-47676*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

FLIGHT EVALUATION OF A PRECISION LANDING TASK FOR A POWERED-LIFT STOL AIRCRAFT

D. M. WATSON, G. H. HARDY, R. C. INNIS, and J. L. MARTIN (NASA, Ames Research Center, Moffett Field, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 214-231. refs
 (AIAA PAPER 86-2130)

A flight research experiment was conducted with the NASA-Ames Research Center's Quiet Short-Haul Research Aircraft to determine the factors which influence the touchdown distribution for a powered-lift STOL aircraft. The pilots were given two tasks for each of a series of precision approaches flown using a microwave landing system (MLS) in simulated instrument meteorological conditions. They flew the aircraft, with forward vision obscured by a screen, to a 100-ft decision height using a flightpath-oriented, color electronic display and one of four levels of control augmentation. Approaches were flown along a nominal 6 deg glidepath, as well as to calibrated offsets at the decision height to establish a variety of initial conditions for the landing task. The screen was removed at the decision height and the pilot was briefed to land in a 200 foot touchdown zone of the STOLport with a sink rate less than 5 ft/sec. Statistical performance envelopes and pilot ratings are used to describe the results of this experiment. The data generated are expected to be useful for establishing STOL aircraft operating requirements and STOL MLS approach criteria.

Author

A86-47677#

THE MIL-PRIME STANDARD FOR AIRCRAFT FLYING QUALITIES

R. J. WOODCOCK and J. T. BROWNE (USAF, Wright-Patterson AFB, OH) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 232-238. refs
 (AIAA PAPER 86-2131)

The new U.S. MIL-Standard and Handbook 'Flying Qualities of Piloted Aircraft' will update requirements for the procurement of aircraft and present them in a novel format, which proceeds through the categories of scope, reference documents, definitions, requirements, verification, and notes. Attention is given to frequency and time response control system specifications, and to pilot rating vs pilot position. Reasons are given for the avoidance of direct use of the Cooper-Harper (1969) standards.

O.C.

A86-47683*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
UNSTEADY LOW-SPEED AERODYNAMIC MODEL FOR COMPLETE AIRCRAFT CONFIGURATIONS
 J. KATZ (NASA, Ames Research Center, Moffett Field, CA) and B. MASKEW (Analytical Methods, Inc., Redmond, WA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 291-302. refs (AIAA PAPER 86-2180)

A method for converting steady state, potential panel methods into a time-dependent mode is derived and applied to several test cases. For this development, an improved vortex wake model was constructed which was also suitable for simulating the leading edge separation of slender wings at high angles of attack. Computed flow-field simulations are presented for various unsteady, and high-angle-of-attack conditions, involving geometries such as simple wings, rotors, and complete aircraft configurations.

Author

A86-47689#
AERODYNAMIC DELAY FOLLOWING CONTROL ACTUATION IN A GLIDER
 R. L. MOORE (Moore Applied Physics Co., Tehachapi, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 352-360. (AIAA PAPER 86-2226)

In the generally accepted equations of motion of aircraft, no provision is made for the time it takes for the external flow to adapt to a change of position of the control. This paper shows, the need for a change to these equations of motion, and provides an analysis of experimental data which shows that the most-probable change is the introduction of aerodynamic lag.

Author

A86-47690*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE ANALYSIS OF AIRLINE FLIGHT RECORDS FOR WINDS AND PERFORMANCE WITH APPLICATION TO THE DELTA 191 ACCIDENT
 R. E. BACH, JR. and R. C. WINGROVE (NASA, Ames Research Center, Moffett Field, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 361-373. refs (AIAA PAPER 86-2227)

Advanced analytical methods applied to airline digital flight records and ATC radar tracking data are providing new insights into atmospheric disturbances that cause serious operating problems for aircraft. Performance-based methods for estimating unmeasured flow angles and the possible influence of rain on lift and drag, and a state-estimation procedure for determining winds along the flightpath are reviewed. The methods are applied to data records from the Delta Flight 191 wind-shear accident at the Dallas/Ft. Worth Airport (August 2, 1985) which involved an L-1011 airliner on final approach. The results indicate that the aircraft encountered a strong downflow followed by a strong outflow accompanied by large and rapid changes in the vertical wind. This pattern of low-level winds is consistent with the model that treats a downburst as a vortex ring. Although rain was present in the downburst, the analysis showed no evidence of performance loss. The results obtained from analyses of airline turbulence encounters provide a means for simulating turbulence phenomena and for training pilots for future encounters.

Author

A86-47692#
STABILITY AND CONTROL OF AIRCRAFT WITH MANUAL ALL-MOVING TAILPLANES
 C. A. MARTIN, J. S. DROBIK, R. M. CARMICHAEL, and S. C. SMITH IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 379-385. (AIAA PAPER 86-2231)

All-moving tailplanes have occasionally been employed by designers on aircraft with manually-operated controls to meet demanding requirements on trimming and manoeuvring. A study of the stability and control characteristics of a light utility aircraft, employing a manually-operated all-moving tailplane is presented. Satisfactory stability and control characteristics can be achieved by pivoting the tailplane aft of its aerodynamic center and by using a geared tab in a balancing sense. The arrangement is shown to give an increase in controls-free stability but can lead to degraded short period response during manoeuvring or during flight in turbulence. It is shown that small amounts of backlash in the tailplane-tab linkage can also lead to degraded short period response. The effects of control circuit inertia and non-linear control surface aerodynamics are investigated. The study emphasizes the need for careful design of the tailplane-tab linkage arrangements and the need for strict mechanical tolerances to be maintained.

Author

A86-47693#
MODELLING OF RIGID-BODY AND ELASTIC AIRCRAFT DYNAMICS FOR FLIGHT CONTROL DEVELOPMENT
 R. A. CALICO (USAF, Institute of Technology, Wright-Patterson AFB, OH), T. E. NOLL (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and J. J. CERRA, II IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 386-395. refs (AIAA PAPER 86-2232)

The purpose of this paper is to develop a linear model of an elastic aircraft. The model provides the capability to analyze the coupling between the rigid and elastic motion of the aircraft. The method developed in this paper obtains stability derivatives directly from unsteady aerodynamic forces. This results in a state-space model whose states are just the normal aircraft states and rates, the structural coordinates and rates, and the control surface positions and rates. Using a representation of the YF-17 wind tunnel flutter model, it is demonstrated that the methodology developed predicted both the rigid-body and flutter behavior of the model. Flutter control laws were designed for motion about an equilibrium condition represented by a velocity 20 percent above the flutter velocity. Both classical and modern technique yielded acceptable control laws. The control laws were also analyzed at off design conditions to check robustness.

Author

A86-47694#
THE DYNAMIC RESPONSE OF A VARIABLE SWEEP AIRCRAFT IN THE COURSE OF CHANGING GEOMETRY
 J. AN (Chinese Aerodynamic Research and Development Center, Sichuan, People's Republic of China), M. YAN, W. ZHOU, X. SUN (Jiaotong University, Shanghai, People's Republic of China), C. QIU (Shanghai Aircraft Co., People's Republic of China) et al. IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 396-406. refs (AIAA PAPER 86-2234)

A numerical method to obtain a complete solution of the dynamic response of a variable sweep wing aircraft in the course of changing the angle of sweep is presented. Both aerodynamic and trajectory computation are included. In aerodynamic computation, the quasi-steady and unsteady aerodynamics of an aircraft in swept change are calculated with a numerical of finite elementary solution method. While deriving equations of flying dynamics, a set of complete equations in main body axes is formed with form-variable system dynamics. The most distinguishing feature

of this paper is its adoption of a time history method to make close cross-computation of aerodynamics and aircraft response. Subsequently, all the aerodynamic and flight dynamics parameters in the whole course of changing geometry of the aircraft are obtained. Using the method described in this paper, the whole swept change course and the influence of each factor in that course on the aircraft response can be satisfactorily analyzed and studied. Computation examples and response analysis are given. All results are very useful for studying flight stability, maneuverability and safety of swept change at low altitude. Author

A86-47695#

ENHANCED CONTROLLABILITY THROUGH VORTEX MANIPULATION ON FIGHTER AIRCRAFT AT HIGH ANGLES OF ATTACK

G. N. MALCOLM and A. M. SKOW (Eidetics International, Inc., Visual Aerodynamics Div., Torrance, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 407-424. refs (Contract F33615-85-C-3619) (AIAA PAPER 86-2277)

Experiments were performed in a flow visualization water tunnel on a generic fighter model to explore vortex manipulation as an effective means of aircraft control by altering the natural state of the forebody and LEX vortices in the medium-to-high-angle of attack range with either small surface modifiers or blowing jets. Specifically, the forebody vortex system was examined with the clean forebody, with forebody strakes, and with forebody surface blowing. LEX vortices were examined with a clean LEX, with small geometric modifications near the apex, and with surface blowing, both in upstream and downstream directions at various locations on the LEX surface. The interactive effects of forebody and LEX/wing vortices and their response to the various methods of control were also examined. Generally, it was concluded that the forebody vortices can be effectively controlled by either blowing or using strakes, but the effectiveness is very dependent on proper radial placement of the blowing port or strake. Geometric modifications and blowing at the LEX apex were not particularly effective in altering the trajectory of the LEX vortices or the burst points. Blowing aft of the mid-chord of the LEX was much more effective and could force the burst points to move forward significantly. Interactions between the forebody and LEX vortex systems were pronounced. Author

A86-47696#

USE OF HINGED STRAKES FOR LATERAL CONTROL AT HIGH ANGLES OF ATTACK

D. T. WARD (Texas A & M University, College Station) and R. E. ERB (USAF, Washington, DC) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 425-438. Research sponsored by the General Dynamics Corp. and Texas A & M University. refs (AIAA PAPER 86-2278)

Static wind tunnel data quantifying the effectiveness of small hinged strakes on a fighter aircraft configuration both compare well with previously obtained data and suggest that the size of such devices may be less important than their placement and effect on the vortex lift structure of the wings. The results obtained also suggest that larger strakes may generate a higher rolling moment/yawing moment ratio, thereby reducing the sideslip excursions produced by hinged strake deflection. Mathematical simulation indicates that an aircraft thus equipped can be maneuvered at angles-of-attack of 30-40 deg, although sideslip has to be tightly controlled. O.C.

A86-47697#

VORTEX-INDUCED EFFECTS ON AIRCRAFT DYNAMICS

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 439-445. refs (AIAA PAPER 86-2279)

At the high angles of attack that modern high performance aircraft operate, vortices generated by a highly swept wing leading edge or a slender forebody strongly influence the vehicle dynamics. The vortex-induced aerodynamic loads are highly nonlinear. Of particular concern are the discontinuous loads generated by sudden changes in the vortex geometry, as they often have an adverse effect on the aircraft dynamics. Examples are the wing rock and wing bending oscillations experienced by aircraft with highly swept wing leading edges. Another example is the interaction occurring between asymmetric forebody vortices and a downstream fin, wing, or horizontal tail surface. Author

A86-47701#

SPHERICAL MAPPING AND ANALYSIS OF AIRCRAFT ANGLES FOR MANEUVERING FLIGHT

J. KALVISTE (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 486-495. (AIAA PAPER 86-2283)

A spherical mapping technique has been developed for displaying attitude angles of aircraft and flightpath in three dimensional maneuvering flight. The three sets of aircraft angles are the Euler angles, flight path angles, and aerodynamic angles. A computer graphics display has been developed. The display shows the interrelationship among these angles. The aircraft axis of rotation and the velocity vector axis of rotation are also shown by the same mapping. Using this display, it is clearly shown that for a coordinated maneuver, the aircraft does not roll about the velocity vector, contrary to popular wisdom. Coordinated maneuver is achieved by rolling the aircraft about the axis of rotation of the velocity vector. The spherical mapping is also used to derive useful relationships among the aircraft angles. Author

A86-47702#

F-5E DEPARTURE WARNING SYSTEM ALGORITHM DEVELOPMENT AND VALIDATION

J. H. TAYLOR and A. M. SKOW (Eidetics International, Inc., Torrance, CA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 496-509. USAF-supported research. (AIAA PAPER 86-2284)

Most fighter aircraft exhibit a departure mode which is predictable, repeatable, and, therefore, avoidable through the use of warning systems and/or flight control limiters. On the other hand, some aircraft, such as the F-5E, have unique departure/spin-entry mechanisms which are impossible to produce at will, are apparently random in occurrence, and are extremely difficult to sense by the pilot. Providing a timely and reliable warning of impending departure is a very difficult problem in these latter kinds of aircraft. This paper summarizes the work done to analyze the F-5E departure characteristics, isolate the critical parameters, derive a departure warning algorithm, and flight validate the system with live air combat maneuvering missions. Results confirmed the feasibility of sensing the aircraft's rotational rates, computing the roll-yaw coupled pitch acceleration, which is the essential ingredient of the F-5E departure, and providing the pilot a warning of the presence of a critical magnitude of this inertial pitch acceleration. The algorithm, in an F-5E Departure Warning System, promises to prevent future inadvertent spin entries, and with appropriate parameter thresholds could be adapted to other aircraft with similar departure mechanisms. Author

A86-47706*# Calspan Corp., Buffalo, N. Y.

EFFECTS OF TIME DELAY AND PITCH CONTROL SENSITIVITY IN THE FLARED LANDING

C. J. BERTHE, C. R. CHALK, N. C. WINGARTEN (Calspan Corp., Buffalo, NY), and W. GRANTHAM (NASA, Langley Research Center, Hampton, VA) AIAA, Atmospheric Flight Mechanics Conference, Williamsburg, VA, Aug. 18-20, 1986. 6 p. NASA-sponsored research. refs
(Contract F33615-83-C-3603)
(AIAA PAPER 86-2075)

Between December 1985 and January 1986, a flared landing program was conducted, using the USAF Total In-Flight simulator airplane, to examine time delay effects in a formal manner. Results show that as pitch sensitivity is increased, tolerance to time delay decreases. With the proper selection of pitch sensitivity, Level 1 performance was maintained with time delays ranging from 150 milliseconds to greater than 300 milliseconds. With higher sensitivity, configurations with Level 1 performance at 150 milliseconds degraded to level 2 at 200 milliseconds. When metrics of time delay and pitch sensitivity effects are applied to enhance previously developed predictive criteria, the result is an improved prediction technique which accounts for significant closed loop items. K.K.

A86-47708*# California Univ., Davis.

BOUNDARY-LAYER TRANSITION EFFECTS ON AIRPLANE STABILITY AND CONTROL

C. P. VAN DAM (California, University, Davis) and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) AIAA, Atmospheric Flight Mechanics Conference, Williamsburg, VA, Aug. 18-20, 1986. 11 p. refs
(AIAA PAPER 86-2229)

Surface contamination of laminar-flow airfoils can significantly modify the location of transition from laminar-to-turbulent boundary-layer flow. The contamination can be the result of insect debris, environmental effects such as ice crystals and moisture due to mist or rain, surface damage, or other contamination adhering to the surface. Location and mode of transition have a dominant effect on the lift-and-drag characteristics of a lifting surface. The influences of laminar boundary-layer flow behavior on airplane stability and control are examined through theoretical results and experimental (wind-tunnel and free-flight) data. For certain airfoils with a relatively steep pressure recovery it is shown that loss of laminar flow near the leading edge can result in premature separation of the turbulent boundary layer and, consequently, in loss of lift and control effectiveness. Aerodynamic modifications which minimize boundary-layer transition effects on airplane stability and control are also discussed. Author

A86-47709#

DYNAMICS OF A HELICOPTER WITH A SLING LOAD

T. RONEN, A. E. BRYSON, JR., and W. S. HINDSON (Stanford University, CA) AIAA, Atmospheric Flight Mechanics Conference, Williamsburg, VA, Aug. 18-20, 1986. 13 p. refs
(AIAA PAPER 86-2288)

A new dynamic model is developed for a helicopter carrying a sling load on a single point suspension, and programmed in a computer code. This formulation of the linearized equations of motion is shown to have advantages in the preparation and verification of the program. The model takes into account the effects of the rotor downwash on the load. The model also accounts for unsteady aerodynamics of bluff body loads: the aerodynamic coefficients are modeled as aerodynamic transfer functions, calculated from the results of dynamic wind tunnel tests. The computer code is used to investigate the open loop characteristics of a typical configuration - a CH-53D helicopter carrying a standard military container. The results in hover show the importance of the effects of the rotor downwash and the unsteady load aerodynamics, which have been ignored previously. New observations of the load yaw mode in forward flight, from linear and nonlinear analysis, suggest a possible way of controlling this mode. Author

A86-47798* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ANGLE-OF-ATTACK ESTIMATION FOR ANALYSIS OF CAT ENCOUNTERS

R. E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) and E. K. PARKS (Arizona, University, Tucson, AZ) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 6.1-1 to 6.1-4. refs

Recent studies of clear-air turbulence (CAT) encounters involving wide-body airliners have been based upon flight-path wind estimates made by analyzing digital flight-data-recorder (DFDR) records and radar records. Such estimates require a time history of the aircraft angle of attack, a record that is not usually included in the DFDR measurement set. This paper describes a method for reconstructing angle of attack that utilizes available flight record and aircraft-specific information associated with an aerodynamic model of the lift coefficient. Results from two wide-body incidents in which vane measurements of angle of attack were recorded show good agreement between measured and calculated time histories. This research has been performed in cooperation with the National Transportation Safety Board to provide a better understanding of the CAT phenomenon. Author

A86-48655

A STUDY OF STABILITY AND CONTROL OF A HINGELESS ROTOR HELICOPTER WITH NON-UNIFORM INDUCED VELOCITY FIELD

Z.-M. XIN (Air Force Research Institute, People's Republic of China) and S.-C. WANG (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 2. Alexandria, VA, American Helicopter Society, 1985, 16 p. refs

A method is given for the calculation of stability and control of a helicopter with a hingeless rotor. The effects of nonuniformity of rotor-induced velocity distribution and blade flapping elasticity are taken into account, and studied in detail. Harmonic terms of rotor-induced velocity distribution derived from the generalized vortex theory of rotor are used. A closed form of equations for the induced velocity and circulation is established. All rotor derivatives are obtained in functions of the rotor advance ratio and its components with respect to the shaft system, and are calculated by the numerical methods. Finally a sample calculation of a typical helicopter is made and it is found that the calculating results are in good agreement with flight test data. Author

A86-48670

HELICOPTER PARAMETER IDENTIFICATION TECHNOLOGY RESEARCH UNDER THE CONSIDERABLY DISTURBING CONDITION

S. YANG (Flight Test Research Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 4. Alexandria, VA, American Helicopter Society, 1985, 13 p.

The present treatment of the forces and moments acting on a typical helicopter derives nonlinear equations of motion, calculates maneuvering loads for the Chinese X-5 helicopter on the basis of a nonlinear model, and compares the nonlinear results obtained to those of a linear model. The nonlinear method reduces errors by more than 50 percent by comparison with the linear alternative. Attention is given to the helicopter's behavior at different times in the course of a maneuver. The application range of the linear model is quantified. O.C.

A86-48671

THE DYNAMIC RESPONSE OF HELICOPTERS TO FIXED WING AIRCRAFT WAKE ENCOUNTERS

H. C. CURTISS, JR. (Princeton University, NJ) and Z.-G. ZHOU (Harbin Aircraft Factory, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 5. Alexandria, VA, American Helicopter Society, 1985, 16 p. DOT-supported research. refs

Fixed wing aircraft may experience a severe upset if they encounter the trailing vortex of a large jet transport. Limited flight experiments using a teetering rotor helicopter indicate that the response of a helicopter to a trailing vortex encounter is considerably less severe. This paper considers the basic nature of the gust response of helicopters and presents a simplified analytical approach to the problem of predicting the response of a single rotor helicopter to a trailing vortex encounter. Consideration is given to the estimation of main rotor flapping as well as the motion of the complete vehicle. The influence of helicopter configuration, main rotor type and helicopter size relative to the vortex on the response is discussed and illustrated by calculation of the dynamic response of various helicopters to an encounter with the trailing vortex of a large transport aircraft. Results are compared to flight test. Basic reasons for the difference in severity of the response of fixed wing aircraft compared to helicopters are discussed. Author

A86-48674

CIVIL HELICOPTER HANDLING QUALITIES REQUIREMENTS FOR VISUAL AND INSTRUMENT FLIGHT

D. A. TUCK (Tuck Aircraft Engineering, Fort Worth, TX) IN: The Theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 5. Alexandria, VA, American Helicopter Society, 1985, 6 p.

A discussion of United States civil helicopter handling qualities requirements, including a brief history of their development, is presented. The organization and operation of the Federal Aviation Administration is presented insofar as its national and international aircraft certification activity is concerned. Basic visual flight certification requirements and additional handling qualities requirements for instrument flight certification are included. Some interesting methods used by manufacturers to improve helicopter handling qualities are also presented. Author

A86-48775

SELF-OSCILLATORY REGIMES OF AIRCRAFT MOTION DURING SPIN-ROLL COUPLING [AVTOKOLEBATEL'NYE REZHIMY DVIZHENIYA SAMOLETA PRI VRASHCHENII PO KRENU]

M. G. GOMAN and V. L. SUKHANOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 50-57. In Russian. refs

An analysis is made of the generation and development of the self-oscillatory regimes of aircraft motion during spin-roll coupling. The stable solutions of the approximate nonlinear equations are examined, and the phase-space structure as the control parameter varies is analyzed. The harmonic-balance method is used to estimate the amplitudes and frequency of oscillatory components of the motion parameters. B.J.

A86-48844

DETERMINATION OF THE STATISTICAL CHARACTERISTICS OF AIRCRAFT MOTION DURING AN AUTOMATIC APPROACH [OPREDELENIE STATISTICHESKIKH KHKARAKTERISTIK DVIZHENIYA SAMOLETA PRI AVTOMATICHESKOM ZAKHODE NA POSADKU]

V. P. KUZMIN and G. V. PARYSHEVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 55-66. In Russian. refs

A method is presented for determining the statistical characteristics of the controlled motion of aircraft along the landing beam in the presence of standard perturbations including wind disturbances and disturbances related to the instability of the

operation of radio landing aids. The probability distribution laws for the aircraft motion parameters characteristic of this problem are determined. Some aspects of the numerical solution of a system of equations for the correlation matrix are discussed. V.L.

A86-48991#

REDUCING FUEL CONSUMPTION BY CYCLIC CONTROL

G. SACHS and T. CHRISTODOULOU (Muenchen, Technische Universitaet, Munich, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 153-160. refs

Fuel consumption in range and endurance flight is considered as an optimal cyclic-control problem. In regard to the range-cruise problem, the incompressible and compressible flight regimes are treated separately because each of them shows specific effects for optimal cyclic flight. The improvements achievable in the incompressible flight regime depend on the altitude range admissible. For the compressible flight regime, it is shown that drag-increase effects represent a key factor limiting the improvements possible by optimal cyclic cruise. Furthermore, the results presented for endurance flight show that it is more improved by optimal cyclic control than range cruise. Author

A86-49004#

ACTIVE FLUTTER SUPPRESSION

A. BRADSHAW, T. RAHULAN, and M. A. WOODHEAD (Salford, University, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 262-273. Sponsorship: Ministry of Defence. refs (Contract MOD-2101/063/XR/ST)

A new theory is presented in this paper which makes use of acceleration components along with other parameters in the design of control systems. This theory is illustrated by designing an integrated digital flight control system to suppress flutter in a wind tunnel model. The understanding of the flutter mechanism led to an approach that was based on forced frequency separation and this method is shown to be very efficient in delaying the onset of flutter. The implementational problems were then examined and a technique is presented which enables the control architecture to be simplified. Digital simulations of transient responses are presented for two different sensor configurations when the model is subjected to a discrete gust. Author

A86-49005#

ACTIVE CONTROL TECHNOLOGY FOR CIVIL TRANSPORT

H. P. Y. HITCH (British Aerospace, PLC, Weybridge, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 274-282. refs

Research in the area of active control technology is considered. The command augmentation system designed from relaxed stability studies permits a reduction in tailplane size of about 20 percent if the aft CG position is as aft as the maneuver point, thereby yielding a 1-1.5 percent reduction in DOC. The load alleviating research focused on reducing the bending loads on wings by half by using a wing load alleviation system. The requirements for maneuver load alleviation (MLA) and gust load alleviation (GLA) systems are discussed. The testing of the relaxed stability, MLA, and GLA in terms of bending-moment shear and torque is described; the test data revealed that the three systems performed well. I.F.

A86-49006#

DESIGNING A LOAD ALLEVIATION SYSTEM FOR A MODERN CIVIL AIRCRAFT

B. W. PAYNE (British Aerospace, PLC, Weybridge, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 283-291.

The design of an active control gust load alleviation system is described, with a design objective of making a direct saving on wing weight. The application of this design to the Airbus Industrie

A320 is discussed, the first such system to be incorporated in a modern civil airliner from the initial design stage. The gust is sensed by accelerometers sited in the forward fuselage. These signals are fed as input to the electrical flying control system computers in which are specified the control laws for the load alleviation system. The computer output then moves outer wing spoilers and ailerons. Use of normal flying controls and systems keeps the installation weight penalty to a minimum. Airworthiness objectives are discussed and reference made to two particular aircraft flight test programmes used both in the development of the system, and in establishing confidence in the feasibility and effectiveness of the system. Author

A86-49023#

DESIGN CRITERIA FOR FLIGHT CONTROL SYSTEMS

G. SCHAEZNER (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 409-419. refs

Design criteria for flight control systems are considered, and the problems of the classical control procedures of cascade control and complete state vector feedback are discussed in contrast to the different design procedures of pole placement and quadratic cost functions. A design procedure is proposed that has been realized in a flight control system, and tested for precise nap of the earth flights. The choice of weighting factors in flight control system design from the aircraft response and the flight control system structure is discussed. R.R.

A86-49025#

HANDLING QUALITIES FOR UNSTABLE COMBAT AIRCRAFT

J. C. GIBSON (British Aerospace, PLC, Military Aircraft Div., Preston, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 433-445. refs

Unstable aircraft depend completely on the flight control system to stabilize the response modes. The resulting pitch handling qualities differ significantly from the conventional ones. Current criteria may be impossible to apply and serious handling problems have been experienced in some recent aircraft. Handling qualities analysis methods are presented which allow previous data from any source to be directly applied to unstable aircraft control design, and which ensure complete freedom from pilot induced oscillations. An example is given of the excellent handling qualities which can be achieved. The unconventional nature of the long period and attitude related responses are discussed. Author

A86-49026#

VALIDATION ON NONSTATIONARY AERODYNAMICS MODELS FOR LONGITUDINAL AEROPLANE MOTION ON THE BASIS OF FLIGHT MEASUREMENTS

V. KOCKA (Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 446-456. refs

On the basis of the physical analysis, basic and simplified models of nondimensional aerodynamic frequency transfers and related nondimensional aerodynamic step admittances have been derived. They comprise separated quasi-stationary and nonstationary parts. The analysis is useful for didactic purposes in flight mechanics and aerodynamics. An objective way is suggested for verification of validity of aerodynamics models used at the airplane design. It is based on flight measurements on a real airplane. For this purpose the loss functions of motion equations for the short period mode of the airplane longitudinal motion were arranged in a special way. They were employed also for verification of the significance of different components of aerodynamics models. Author

A86-49039*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIMENTAL STUDY OF EFFECTS OF FOREBODY GEOMETRY ON HIGH ANGLE OF ATTACK STATIC AND DYNAMIC STABILITY AND CONTROL

J. M. BRANDON, D. G. MURRI, and L. T. NGUYEN (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 560-572. refs

A series of low-speed wind tunnel tests on a generic airplane model with a cylindrical fuselage were made to investigate the effects of forebody shape and fineness ratio, and fuselage/wing proximity on static and dynamic lateral/directional stability. In addition, some preliminary testing to determine the effectiveness of deflectable forebody strakes for high angle of attack yaw control was conducted. During the stability investigation, 11 forebodies were tested including three different cross-sectional shapes with fineness ratios of 2, 3, and 4. In addition, the wing was tested at two longitudinal positions to provide a substantial variation in forebody/wing proximity. Conventional force tests were conducted to determine static stability characteristics, and single-degree-of-freedom free-to-roll tests were conducted to study the wing rock characteristics of the model with the various forebodies. Flow visualization data were obtained to aid in the analysis of the complex flow phenomena involved. The results show that the forebody cross-sectional shape and fineness ratio and forebody/wing proximity can strongly affect both static and dynamic (roll) stability at high angles of attack. These characteristics result from the impact of these factors on forebody vortex development, the behavior of the vortices in sideslip, and their interaction with the wing flow field. Preliminary results from the deflectable strake investigation indicated that forebody flow control using this concept can provide very large yaw control moments at stall and post-stall angles of attack. Author

A86-49041#

FLIGHT PATH RECONSTRUCTION - A POWERFUL TOOL FOR DATA COMPATIBILITY CHECK

K.-O. PROSKAWETZ and R. BROCKHAUS (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 583-588. refs

The test aircraft and its measuring equipment are described. The nonlinear equations used for the data compatibility check are given after a short introduction of the theoretical background. Results of the compatibility check are shown in time histories and in tabular form. The parameter estimation using compatible data and a model which includes corrections estimated in the compatibility check give very good results. The paper closes with some physical aspects for further improvement of parameter estimation. Author

A86-49047*# Vigyan Research Associates, Inc., Hampton, Va.

FOREBODY VORTEX MANAGEMENT FOR YAW CONTROL AT HIGH ANGLES OF ATTACK

D. M. RAO (Vigyan Research Associates, Inc., Hampton, VA), C. MOSKOVITZ (North Carolina State University, Raleigh), and D. G. MURRI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 651-661. NASA-USAF-supported research. refs

The yaw-control potential of deployable forebody strakes at angles of attack above the range of conventional rudder effectiveness has been investigated. The conformally-stored strakes when deployed force asymmetrical vortex shedding from the forebody, thereby generating a controlled yawing moment. The concept was explored through low-speed wind tunnel tests on a conical forebody in isolation and in a generic fighter configuration. Force and moment measurements on the complete model were supplemented with circumferential pressure and flow-visualization

surveys on an isolated forebody, in order to gain insight into the vortex flow mechanisms resulting from forced asymmetrical separations and to quantify the obtainable yaw power at angles of attack to 80 deg. This preliminary, low-Reynolds-number study showed asymmetrical-deployed forebody strakes to have considerable yaw control potential, whose sensitivity to scale effects needs further investigation. Author

A86-49048#

PREDICTION OF THE AERODYNAMIC CHARACTERISTICS OF FLIGHT VEHICLES IN LARGE UNSTEADY MANEUVERS

M. R. MENDENHALL, S. C. PERKINS, JR., and D. J. LESIEUTRE (Nielsen Engineering and Research, Inc., Mountain View, CA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 662-675. Research supported by the Nielsen Engineering and Research, Inc. refs

A rational flow model to predict the nonlinear aerodynamic forces and moments on a flight vehicle undergoing steady and unsteady maneuvers at subsonic speeds is described. The major physical flow phenomena over the missile are simulated, including the lee-side separation vorticity. The mutual interaction between the vehicle and the time-dependent flow field is considered in the prediction of the unsteady aerodynamic characteristics at any specified instant in time. The aerodynamic prediction method is coupled with a six-degree-of-freedom equation-of-motion solver to predict missile trajectories, or it is used for models undergoing forced trajectories or oscillating motions. The prediction method is verified by comparison with experimental data where possible.

Author

A86-49056#

THE ESTIMATION OF THE STABILITY AND CONTROL CHARACTERISTICS OF A CANARD CONFIGURED COMBAT AIRCRAFT HAVING A FORWARD SWEEP WING

M. V. COOK and F. HEYDARI (Cranfield Institute of Technology, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 730-738. Research sponsored by the Ministry of Defence (Procurement Executive). refs

A program of research has been undertaken in which the principal objective has been to investigate the stability and control characteristics of a generalized canard configured combat aircraft having a forward swept wing. A detailed design study was undertaken to produce an aircraft configured for optimum aerodynamic performance whilst retaining defined, but adjustable, stability margins. A dynamically scaled wind tunnel model with active controls was built and flown on a purpose built test rig in a low speed wind tunnel. Model motion was limited by the test rig to the four degrees of freedom in roll, pitch, yaw and heave. Tests were carried out in which the control input and model response time histories were recorded and stored in digital data files for subsequent analysis. A parameter estimation program using an extended Kalman filter algorithm was written and developed to analyse the response data and from which the output was a set of estimated stability derivatives. This work has produced some very credible results which compare favorably with similar results estimated by less sophisticated means. In this paper the development of the Kalman filter algorithm and its application to the experimental facility is described and presented with some typical results.

Author

A86-49057*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ESTIMATION OF AERODYNAMIC PARAMETERS FROM FLIGHT DATA OF A HIGH INCIDENCE RESEARCH MODEL

V. KLEIN (NASA, Langley Research Center; George Washington University, Hampton, VA) and M. H. MAYO (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 739-747. refs

A procedure for the determination of an aerodynamic model structure and aerodynamic parameters is applied to flight data from a high-incidence research model (HIRM) within an angle of attack range of 18 to 40 degrees. The HIRM is a three-surface unpowered model with a swept wing, an all-moving canard and stabilator, and a vertical tail with rudder. The motion of the HIRM was excited first by its release from the helicopter and then by the activation of control surfaces. This paper briefly describes the model, flight and wind tunnel data available, equations of motion and techniques for data analysis. The results presented contain an example of a measured data compatibility and the variation of some important stability derivatives with the angle of attack and canard setting. The derivatives were obtained from various maneuvers and subsets of joined data from several maneuvers by using a stepwise-regression technique. These derivatives agreed, in general, with the results of wind-tunnel measurements. The resulting lateral aerodynamic model equations could predict the motion of the HIRM reasonably well.

Author

A86-49070*# Princeton Univ., N. J.

OPTIMAL CONTROL LAWS FOR MICROBURST ENCOUNTER

R. F. STENGEL (Princeton University, NJ) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 870-877. FAA-supported research. refs

(Contract NGL-31-001-252)

Simplified structures for longitudinal control laws that reduce an aircraft's response to the strong head-tailwind and downdraft variations associated with microbursts are presented. They are based on non-zero-set-point linear-quadratic regulators that command throttle setting and angle of attack as functions of velocity and flight path angle, and they can incorporate direct measurements of the wind profile if available. Selection of cost functions to be minimized by feedback control has been aided by a prior study of classical control laws and exact nonlinear-optimal flight paths through realistic microburst wind profiles. The resulting optimal control laws have an adaptive, dual-mode structure that can be implemented either in flight-director logic or in an autopilot.

Author

A86-49071*# Rice Univ., Houston, Tex.

OPTIMIZATION AND GAMMA/THETA GUIDANCE OF FLIGHT TRAJECTORIES IN A WINDSHEAR

A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 878-899. Research supported by the Boeing Commercial Aircraft Co. refs

(Contract NAG1-516)

Guidance schemes for near-optimum performance in wind shear are examined. The presence of a downdraft is assumed in addition to the horizontal shear. The takeoff problem is considered with reference to flight in a vertical plane. Trajectories for optimum performance in a wind shear are determined for different wind shear models and intensities. Methods of optimal control theory are used together with the dual sequential gradient-restoration algorithm for optimal control problems. Guidance schemes for near-optimum performance in a wind shear are developed, starting from optimal trajectories. These are gamma guidance, based on either the absolute or the relative path inclination, and theta guidance, based on the pitch attitude angle. These schemes are

evaluated through numerical experiments in order to determine whether the resulting trajectories are sufficiently close to optimum and to compare these trajectories with those arising from alternative guidance schemes. C.D.

A86-49096#

RESEARCH ON ACTIVE SUPPRESSION TECHNOLOGY FOR WING/AILERON FLUTTER

D. M. ZHU, Z. Q. GU, M. H. CAN, Z. F. CHEN, and W. P. WANG (Nanjing Aeronautical Institute, People's Republic of China) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1141-1150.

The active suppression technology of wing/aileron flutter is investigated. The combination of analytical methods with experimental approaches to establish mathematical models for servo-aeroelastic systems is discussed as well as the use of suboptimal output feedback control theory to synthesize control laws for wing/aileron flutter, and the ground and wind-tunnel experimental techniques of aeroelastic systems. Author

A86-49139

DESIGN OF A NONLINEAR LEVER-TYPE MECHANISM FOR AIRCRAFT CONTROL SYSTEMS [NAVRH PAKOVEHO NELINEARNIHO MECHANISMU DO SYSTEMU RIZENI LETOUNU]

M. FALTUS Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1986, p. 29-34. In Czech.

The paper presents fundamental reasons leading to a need for applying the aircraft control system with the nonlinear transfer characteristic. Furthermore, attention is given to the design of the nonlinear lever-type mechanism which, owing to its easy construction, suits most of the indicators best. The mathematical analysis of the problem is followed by simplifying assumptions classifying the problem into several operations. In conclusion, the flow chart realizing the calculation of the given nonlinear mechanism is presented. Conclusions indicate that the diagram of a six-member plane mechanism satisfactorily meets the demands made upon the nonlinear leverage. Author

A86-49244#

AIRPLANE LANDING BEHAVIORS CONTROLLED BY MAN-PILOTS

I. SUGIURA (Nagoya University, Japan) Nagoya University, Faculty of Engineering, Memoirs (ISSN 0027-7657), vol. 37, no. 2, 1985, p. 173-202.

Photographic records of light-aircraft and transport-aircraft landing maneuvers obtained at two Japanese airports in 1972 are presented and analyzed statistically. Data on altitude, attitude angle, and descent velocity and on the atmospheric conditions at the time of landing are given in tables, graphs, and histograms. Of the 89 landings observed, only one is considered potentially dangerous. T.K.

A86-49476

EXPERTS SYSTEM CONTROL OF AUTONOMOUS AIRBORNE VEHICLE

J. F. GILMORE (Georgia Institute of Technology, Atlanta) and W. G. PEMBERTON (Martin Marietta Corp., Orlando, FL) Unmanned Systems, vol. 4, Summer 1985, p. 8-13. refs

Attention is given to the application of AI to airborne autonomous vehicle systems encompassing sensor vision, mission planning, and mission control tasks. Vision furnishes local and global scene analyses that are symbolically represented and passed on to planning, thereby providing initial route planning constraints. Planning then generates a task-dependent path for vehicle traversal, assuring maximum system safety as well as effectiveness. Control, finally, validates the path and either executes the given route or feeds back to the previous two systems in order to resolve conflicts. A typical autonomous airborne vehicle mission in which the autonomous flight vehicle is a helicopter is presented. O.C.

N86-31566# Societe Nationale Industrielle Aerospatiale, Paris (France).

ANEMOBAROMETRY: AN ESSENTIAL ELEMENT OF FLIGHT CONTROL [L'ANEMOBAROMETRIE: ELEMENT ESSENTIEL DE LA CONDUITE DU VOL]

J. BARDOU In *its Anemobarometry in Flight Control*. A-320 Aerodynamics. The Turboreactors Air Inlet 3 p 1985 In FRENCH

Avail: NTIS HC A02/MF A01

The exploitation of the atmospheric pressure to determine flight altitude is reviewed and the calibrating procedures are described. The utilization of ground based radars and towed cones in calibrating anemometric altimeters is discussed. An analysis of the measurement errors is included. ESA

N86-31590*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.

FLIGHT CONTROL SYNTHESIS FOR FLEXIBLE AIRCRAFT USING EIGENSPACE ASSIGNMENT

J. B. DAVIDSON and D. K. SCHMIDT Jun. 1986 230 p (Contract NAG1-254)

(NASA-CR-178164; NAS 1.26:178164) Avail: NTIS HC A11/MF A01 CSCL 01C

The use of eigenspace assignment techniques to synthesize flight control systems for flexible aircraft is explored. Eigenspace assignment techniques are used to achieve a specified desired eigenspace, chosen to yield desirable system impulse residue magnitudes for selected system responses. Two of these are investigated. The first directly determines constant measurement feedback gains that will yield a close-loop system eigenspace close to a desired eigenspace. The second technique selects quadratic weighting matrices in a linear quadratic control synthesis that will asymptotically yield the close-loop achievable eigenspace. Finally, the possibility of using either of these techniques with state estimation is explored. Application of the methods to synthesize integrated flight-control and structural-mode-control laws for a large flexible aircraft is demonstrated and results discussed. Eigenspace selection criteria based on design goals are discussed, and for the study case it would appear that a desirable eigenspace can be obtained. In addition, the importance of state-space selection is noted along with problems with reduced-order measurement feedback. Since the full-state control laws may be implemented with dynamic compensation (state estimation), the use of reduced-order measurement feedback is less desirable. This is especially true since no change in the transient response from the pilot's input results if state estimation is used appropriately. The potential is also noted for high actuator bandwidth requirements if the linear quadratic synthesis approach is utilized. Even with the actuator pole location selected, a problem with unmodeled modes is noted due to high bandwidth. Some suggestions for future research include investigating how to choose an eigenspace that will achieve certain desired dynamics and stability robustness, determining how the choice of measurements effects synthesis results, and exploring how the phase relationships between desired eigenvector elements effects the synthesis results. Author

N86-31591*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DEVELOPMENT OF A TAKEOFF PERFORMANCE MONITORING SYSTEM

R. SRIVATSAN (Kansas Univ., Lawrence), D. R. DOWNING, and W. H. BRYANT Aug. 1986 11 p Presented at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986

(NASA-TM-89001; NAS 1.15:89001) Avail: NTIS HC A02/MF A01 CSCL 01C

The development and testing of a real-time takeoff performance monitoring system is discussed. The algorithm is made up of two segments: a pretakeoff segment and a real-time segment. One-time inputs of ambient conditions and airplane configuration information are used in the pretakeoff segment to generate schedule performance data for that takeoff. The real-time segment uses the scheduled performance data generated in the pretakeoff

08 AIRCRAFT STABILITY AND CONTROL

segment, runway length data, and measured parameters to monitor the performance of the airplane throughout the takeoff roll. Airplane and engine performance deficiencies are detected and annunciated. An important feature of this algorithm is the one-time estimation of the runway rolling friction coefficient. The algorithm was tested using a six degree of freedom airplane model in a computer simulation. Results from a series of sensitivity analysis are also included.

Author

N86-31592# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

ON THE HANDLING QUALITIES OF FLIGHT VEHICLES THROUGH VARIABLE FLIGHT CONDITIONS M.S. Thesis

K. C. GREEN Jan. 1986 100 p
(AD-A167727; AFIT/CI/NR-86-56T) Avail: NTIS HC A05/MF A01 CSCL 20D

Specifications of flight vehicle handling qualities are currently based on the solution of linear, constant coefficient equations of motion, even when certain flight vehicles encounter continuously varying conditions in parts or all of their flight regime. This thesis develops an approach to encompass flight vehicle dynamics that vary during the performance of piloted tasks in the specification of handling qualities. Asymptotic methods, particularly Generalized Multiple Scales, are used to develop approximate analytical solutions to time-varying equations of motion. The solutions are valid throughout the time of variation, with constant flight conditions as a special case. Two classes of flight vehicles are examined to demonstrate the application of asymptotic methods to obtaining parameters pertinent to handling quality analyses. Extensions to existing criteria are suggested. This treatment of variable dynamics can give a clearer understanding of the response characteristics, and therefore of the stability and control requirements, of many piloted vehicles.

GRA

N86-31593# European Space Agency, Paris (France).

ON CONTROL CONCEPT FOR IN-FLIGHT SIMULATION INCLUDING ACTUATOR NONLINEARITIES AND TIME DELAYS

F. HEBSCHER Nov. 1985 67 p Original language document was announced as N86-10047
(ESA-TT-948; DFVLR-FB-85-24; ETN-86-97581) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne, West Germany DM 23.50

A model-following system was developed to study the dynamic behavior of transport aircraft with reduced longitudinal stability. The system is divided into two parts. The first consists of feedforward branches. If a linear description of the model and the basic aircraft is assumed an exact model-following is achieved by this part. For the control matrices algebraic expressions are derived. In the equations the influence of actuator dynamics is considered. A set of formulas in which all variables are assumed to be discretized for processing on a digital computer is developed. By the second subsystem an error suppression is achieved. The application of a cost vector method is demonstrated for one example. It is shown that nonlinearities and time lags can be included in the calculation of the feedback gains.

ESA

N86-32439 Purdue Univ., West Lafayette, Ind.

AN APPROACH TO INTEGRATED AEROSERVOELASTIC TAILORING FOR STABILITY Ph.D. Thesis

T. A. ZEILER 1985 123 p
Avail: Univ. Microfilms Order No. DA8529352

A fundamental study of the problem of combined structural and control design for aeroelastic behavioral objectives, called integrated aeroservoelastic tailoring, is conducted. First, behavioral characteristics of two idealized aeroservoelastic models are studied. These models are a 3 degree-of-freedom airfoil and a 4 degree-of-freedom aircraft idealization, the latter incorporating the 3 degree-of-freedom airfoil elastically attached to a fuselage with freedom in body pitch. Structural design parameters are the shear center and airfoil position, control synthesis is accomplished with optimal steady-state linear quadratic regulator theory. Control design parameters include the control design speed and elements of the output weighting matrix in the quadratic cost function used

in the control synthesis. Second, aeroservoelastic tailoring is posed as a multi-disciplinary optimization problem to which is applied multilevel linear decomposition, breaking the aeroservoelastic system down into structural and control subsystems. For the present study, the design objective is a maximized stable airspeed envelope with the subsystem designs constrained to be optimal in some way. The control subsystem is the optimal steady-state linear quadratic regulator. The structural subsystem is not modeled in detail. An iterative design technique is then applied to the two models. Results show that the technique yields optimally controlled configurations with superior stability boundaries. The technique also provides a rational means for determining changes in structural and control design parameters to effect desired changes in system performance.

Dissert. Abstr.

N86-32440*# Kansas Univ. Center for Research, Inc., Lawrence.

PRELIMINARY CONTROL LAW AND HARDWARE DESIGNS FOR A RIDE QUALITY AUGMENTATION SYSTEM FOR COMMUTER AIRCRAFT. PHASE 2

D. J. DAVIS, D. J. LINSE, R. SUKAT, and D. P. ENTZ Sep. 1986 261 p

(Contract NAG1-345)

(NASA-CR-4014; NAS 1.26:4014; KU-FRL-6132-2) Avail: NTIS HC A12/MF A01 CSCL 01C

The continued investigation of the design of Ride Quality Augmentation Systems (RQAS) for commuter aircraft is described. The purpose of these RQAS is the reduction of the vertical and lateral acceleration response of the aircraft due to atmospheric turbulence by the application of active control. The current investigations include the refinement of the sample data feedback control laws based on the control-rate-weighting and output-weighting optimal control design techniques. These control designs were evaluated using aircraft time simulations driven by Dryden spectra turbulence. Fixed gain controllers were tested throughout the aircraft operating envelope. The preliminary design of the hardware modifications necessary to implement and test the RQAS on a commuter aircraft is included. These include a separate surface elevator and the flap modifications to provide both direct lift and roll control. A preliminary failure mode investigation was made for the proposed configuration. The results indicate that vertical acceleration reductions of 45% and lateral reductions of more than 50% are possible. A fixed gain controller appears to be feasible with only minor response degradation.

Author

N86-32444# Societe Nationale Industrielle Aerospatiale, Paris (France). Div. Helicopters.

ACTIVE CONTROL OF HELICOPTER VIBRATIONS. FLIGHT EVALUATION OF A VIBRATION REDUCTION SYSTEM ON A GAZELLE SA 349 HELICOPTER [CONTROLE ACTIF DES VIBRATIONS SUR HELICOPTERE. EVALUATION EN VOL D'UN SYSTEME PROBATOIRE SUR GAZELLE SA 349]

M. POLYCHRONIADIS and M. ACHACHE 1986 28 p In FRENCH Presented at 42nd Forum AHS, Jun. 1986
(SNIAS-861-210-108; ETN-86-97593) Avail: NTIS HC A03/MF A01

A multicyclic vibration reduction system was tested in real helicopter flight. The self-adapting system is composed of a digital computer, an analog computer, a vibration measuring system composed of accelerometers placed in the cabin, and three electrohydraulic output devices which can modify the wing incidence angle by up to 1.6 deg. The computing algorithms estimate the optimum command function. Adaptive deterministic or stochastic algorithms were tested. Vibration reductions of 80% are obtained.

ESA

N86-32445# European Space Agency, Paris (France).
IDENTIFICATION OF GUST INPUT AND GUST RESPONSE CHARACTERISTICS FROM DO 28 TNT FLIGHT TEST DATA
 D. ROHLF Dec. 1985 65 p Transl. into ENGLISH from "Ermittlung der Boe und des Boenstoerverhaltens aus Flugversuchsdaten am Beispiel Do 28 TNT" Brunswick, West Germany Original report in German previously announced as N85-27881

(ESA-TT-919; DFVLR-FB-84-48; ETN-86-98075) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne, West Germany DM.21

A method to determine gust response characteristics and simultaneously estimate the discrete gust input from flight test data using system identification techniques is presented. The method is restricted to longitudinal motion of aircraft with separated wing and tail surfaces at low Mach numbers. The applicability of the method is demonstrated by analyzing free flight catapult tests and dynamic wind-tunnel tests with models of the Do 28 TNT aircraft. A good fit of the measured and identified time histories is achieved by considering the dynamic terms which are important for angles of attack varying rapidly due to gusts. ESA

N86-32446# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abteilung Regelung.

SERVO-ACTUATOR FOR SAMPLED-DATA FEEDBACK DISTURBANCE REJECTION Ph.D. Thesis - Ruhr University
 J. PETRY Jan. 1986 199 p In GERMAN; ENGLISH summary (DFVLR-FB-86-08; ISSN-0171-1342; ETN-86-97818) Avail: NTIS HC A09/MF A01; DFVLR, Cologne, West Germany DM 57.50

Based on a helicopter it is demonstrated why discrete feedback control for disturbance rejection using a pulse-amplitude-modulated control signal can cause undesired disturbing effects. This analysis is done in the frequency domain by frequency responses, and by spectral decompositions of the signals concerned. The results provide recommendations for a controller design. A continuous minor-loop feedback control which allows the continuous plant to be appropriately adjusted to the characteristics of discrete disturbance rejection is proposed. The efficiency of this approach is confirmed by design examples and simulations. ESA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A86-47304

DESIGN OF A FAST RISETIME LIGHTNING GENERATOR

J. L. HEBERT, L. C. WALKO (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and J. G. SCHNEIDER (Technology/Scientific Services Inc., Dayton, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 115-119.

It has been verified through analytical and smaller scale experimental studies that a NEMP-type peaking capacitor could be coupled with a high voltage EMP simulator to provide the fast current risetimes that have been observed during recent ground and in-flight lightning research programs. The Atmospheric Electricity Hazards (AEH) Group of the Air Force's Wright Aeronautical Laboratories has built and demonstrated a fast risetime generator, using a peaking capacitor which is capable of applying currents of 20 kA to 40 kA with risetimes of 100 nsec to 200 nsec onto an operational aircraft. The generator was used during 1984 for lightning simulation tests on the specially instrumented FAA CV-580 lightning research aircraft, a GF-16

prototype aircraft and a specially instrumented lightning strike object (LSO) in a coaxial geometry return path. Author

A86-47662*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

USE OF FLIGHT SIMULATION TO DEVELOP TERMINAL INSTRUMENT PROCEDURES FOR TRANSPORT CATEGORY AIRCRAFT

J. R. BRANSTETTER (NASA, Langley Research Center; FAA, Hampton, VA) and J. A. HOUCK (NASA, Langley Research Center, Hampton, VA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 78-85. refs

(AIAA PAPER 86-2072)

In a collaborative effort between the FAA and NASA, a simulation was conducted to look at the issues involved with flying a large, widebody aircraft in the terminal area using MLS-RNAV procedures. A variety of approach paths, departure paths, and holding patterns were investigated during the course of the study, which included the participation of subject pilots. The simulation made use of paths designed by the FAA Office of Aviation Standards and employed Langley's Visual Motion Simulator (VMS) for their execution. Data obtained from this simulation will be used to support the joint FAA/USAF MLS flight test and demonstration project. This paper describes the flight simulation facility adapted to model terminal area maneuvers for jet transport aircraft using the Microwave Landing System (MLS). A description of the overall project will be presented first, along with a discussion of the guidance schemes used, followed by a description of the simulation hardware and software. A sample of the resulting data will also be presented. Author

A86-47663#

FLIGHT SIMULATION OF MLS INTERCEPTION PROCEDURES APPLICABLE TO Laterally SEGMENTED APPROACH PATHS

L. J. J. ERKELENS and P. J. VAN DER GEEST (Nationaal Lucht-en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 86-96. refs (AIAA PAPER 86-2073)

In addition to the use of the Microwave Landing System (MLS) as a guidance aid for segmented or curved approach path tracking, MLS can also be utilized during the interception phase of these approach paths. Within this scope a theoretical study was carried out on the design and implementation of MLS guided interception procedures, applicable to segmented approach paths. As a result of this study, four MLS procedures, each considered to serve an essential operational purpose, were proposed for further evaluation. Moreover, various guidance systems based on both closed loop and open loop turn concepts, were evaluated with respect to their capabilities of providing accurate tracking guidance. Based on these results a subsequent simulator investigation was executed in which aspects were analyzed, concerning: the feasibility of the four proposed interception procedures, the appropriate turn techniques: (closed loop or open loop turns), and the avionics equipment required for these procedures. The avionics included an experimental navigation display, especially developed to be used with the MLS interception procedures. Test results consisted of both objective and subjective data. The objective data concerned: recorded path deviations and statistical data concerning tracking performance and control activity. Subjective data were derived from: pilot effort ratings, questionnaire responses and comments of pilots and air traffic controllers. Author

A86-47664* # National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PILOT EVALUATION OF EXPERIMENTAL FLIGHT TRAJECTORIES IN THE NEAR-TERMINAL AREA
 R. DELOACH and J. A. HOUCK (NASA, Langley Research Center, Hampton, VA) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 97-110. refs
 (AIAA PAPER 86-2074)

Advanced cockpit avionics systems now under development at NASA Langley Research Center will provide the means for effectively utilizing MLS technology to achieve a number of important objectives in the near-terminal airspace. A simulator study has recently been completed at NASA Langley Research Center in which guest pilots from a number of airlines were asked to fly curved ground tracks designed to avoid population centers in four airport communities. Eight two-man crews comprised of commercial line pilots, and three NASA crews each evaluated a total of eight departures and eight approaches on the basis of such factors as workload, safety, passenger acceptance, controllability, and piloting skill. Various physical measurements were also made, including cross-track errors, altitude errors, bank angles, and fuel flow rates. Half of the trajectories were curved and designed to be population-minimal, and half were designed to represent conventional ground tracks. The objective of the study was to determine if statistically significant differences could be detected between curved and conventional ground tracks on the basis of these parameters. Author

A86-47791
FROM MAINFRAME TO MICRO - STRUCTURES AND FLUTTER TESTING AT THE AIR FORCE FLIGHT TEST CENTER
 R. W. LENZ (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 4.5-1 to 4.5-9.

The Air Force Flight Test Center (AFFTC) upgraded its flutter and structures test data acquisition and analysis system in 1984. The new system was based on using portable, super microcomputers. This paper briefly discusses the evolution of flutter and structures testing and data analysis at the AFFTC and describes the current data acquisition and analysis system. The paper includes a discussion of lessons learned during the development of the AFFTC structures testing concept. The current concept involves having a data system in any flight test control room, a work station in the engineer's office, and the ability to quickly transport the data system to support offsite testing. The current AFFTC system is based on a small (12 inch x 16 inch x 30 inch), multiuser computer system which has high performance data acquisition (one million samples per second), data reduction (floating point and array processors), data display (independent color graphics processors), and data output (disk and tape storage and high speed printer/plotters). Author

A86-47792
ADVANCED ICING WIND TUNNEL FOR FLIGHT TEST DEVELOPMENT OF ICING RATE SYSTEMS
 L. WEBB (Rosemount, Inc., Burnsville, MN) IN: Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985 Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1985, p. 4.6-1 to 4.6-4.

An icing wind tunnel has been constructed which simulates all natural icing environments required for helicopter certification. The facility is a closed loop, low speed wind tunnel with a 10 sq in, 2 ft-length test section. Accuracy, stability, and repeatability of the velocity, temperature, droplet size and liquid water content parameters are insured by the ability to operate the wind tunnel controls either manually or by computerized means. Attention is given to initial operation results and development problems. O.C.

A86-48041
CATAPULT HOLDBACK DESIGN EXAMINED
 Aerospace Engineering (ISSN 0736-2536), vol. 6, July 1986, p. 26-31.

Prior to carrier aircraft launch, a 'holdback and release' device is used to restrain the aircraft against the maximum thrust developed by its engines and the tension forces generated by its catapult. While such holdback bars have in the past been frangible link-incorporating devices designed to fail at a predetermined load level to initiate launch, a novel system is presented which is fully reusable. In this mechanism, a small and highly loaded secondary lock element is used to trigger a larger, main load-carrying primary lock element. The lower loads of the secondary elements allow a more precise control of the triggering action. O.C.

A86-48371
AIRPORTS BUILD FOR FUTURE TRAFFIC AMID NEW SECURITY CONCERN
 D. WOOLLEY Interavia (ISSN 0020-5168), July 1986, p. 763, 764, 767-770.

An evaluation is made of the financial, technical, commercial, and security-related factors currently influencing major international airport construction, renovation and expansion programs. Attention is given to such new technologies as mobile X-ray equipment for baggage inspection by the side of aircraft, automated handling of containerized baggage and freight, ground-movement radars, and large departures/arrivals display technology. Progress toward the detection of explosives and fire-arms by pencil-beam and two-beam X-ray machines is assessed. O.C.

A86-48457
TESTS ON CAST 7 AND CAST 10 PROFILES IN THE T2 ADAPTIVE-WALL CRYOGENIC WIND TUNNEL - STUDY OF THE REYNOLDS-NUMBER EFFECT IN NATURAL AND TRIGGERED TRANSITIONS [ESSAIS DE PROFILS CAST 7 ET CAST 10 DANS LA SOUFFLERIE CRYOGENIQUE A PAROIS ADAPTABLES T2 - ETUDE DE L'EFFET REYNOLDS EN TRANSITION NATURELLE ET EN TRANSITION DECLENCHEE]
 A. BLANCHARD, J. B. DOR, A. MIGNOSI, and A. SERAUDIE Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 22nd, Lille, France, Nov. 13-15, 1985. 48 p. In French. refs
 (AAAF PAPER NT 85-06)

The effects of increasing Reynolds number (in the range 3-30 x 10 to the 6th) on the flow over precooled 150-mm-chord CAST 7 and 180-mm-chord CAST 10 supercritical wing profiles is investigated experimentally in the ONERA T2 wind tunnel. The results are presented in graphs, and it is found that the performance of the wing improves with increasing Reynolds number in the case of a triggered transition, while the position of the natural transition changes with Reynolds number and gives rise to inverse effects. It is pointed out that the realistic Reynolds numbers obtained using an adaptive-wall cryogenic wind tunnel do not eliminate the other problems inherent in wind-tunnel tests (e.g., nonsimilarity of models, model surface characteristics, parasitic effects). T.K.

A86-48673
GROUND BASED HELICOPTER SIMULATION
 J. J. HOWLETT (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 5. Alexandria, VA, American Helicopter Society, 1985, 15 p. refs

This paper examines the reasons for the expanding role of rotorcraft ground based simulation and the broad range of requirements for both analytical and piloted simulation support in an industrial setting such as that existing at Sikorsky Aircraft. In order to be effective in supporting these requirements a highly structured approach to simulation was developed based on a modular library system. This approach and its attributes are discussed, together with a presentation of the analytical content of the primary modules comprising the system library. The level

of sophistication believed necessary is identified. This paper also addresses some of the issues associated with simulation, in particular, the requirements of real-time simulation and how it can be accommodated. The facility hosting this simulation system is briefly described. The process of verification and validation of simulation is outlined and noted as being essential for confidence in its application to design. It is concluded that simulation must expand beyond the traditional requirements of handling qualities and embrace the needs of total system integration. Author

A86-49024#

FLIGHT SIMULATION TECHNIQUES WITH EMPHASIS ON THE GENERATION OF HIGH FIDELITY 6 DOF MOTION CUES

M. BAARSPUL (Delft, Technische Hogeschool, Netherlands) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 420-432. refs

The current status of flight simulation technology has reached the level where the aircraft dynamics can be simulated with the fidelity required for 'Total Simulation' in civil air crew training. In the first part of this paper the main systems of a piloted flight simulator will be discussed: (1) the real-time digital computer system driving the simulator; (2) the simulator cockpit providing various levels of equipment fidelity to the pilot; (3) visual systems where improved display devices should take advantage of improvements in CGI-systems; and (4) motion systems generating aircraft-like specific forces and angular accelerations. Special emphasis will be placed on a unique method to generate high fidelity six-degrees-of-freedom (6 DOF) motion cues in the second part of the paper. Time responses of the specific forces, and angular accelerations generated in the aircraft cockpit, will be compared to the same quantities generated in the simulator cockpit on top of a 6 DOF motion system. The control surface inputs, generating these time responses, result from so-called 'Flight Simulator Critical Maneuvers'. Author

A86-49058#

ADVANCES AT AEDC IN TREATING TRANSONIC WIND TUNNEL WALL INTERFERENCE

E. M. KRAFT, A. RITTER (Calspan Corp., Arnold Air Force Station, TN), and M. L. LASTER (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 748-769. refs

The development and status of techniques to determine or minimize the effects of wall interference in wind tunnel tests of three-dimensional aircraft at high transonic speeds are considered. It is shown how pretest predictions of three-dimensional transonic wall interference are now routinely performed for production wind tunnel tests using advanced numerical techniques and an improved mathematical description of perforated walls. In situ wall interference assessment/correction techniques developed for three-dimensional transonic flow and a preliminary evaluation using numerical simulations are described. Finally, a three-dimensional variable porosity adaptive wall system which has successfully eliminated wall interference at near sonic conditions is discussed. C.D.

A86-49059#

NUMERICAL DESIGN PARAMETER STUDY FOR SLOTTED WALLS IN TRANSONIC WIND TUNNELS

N. AGRELL, B. PETTERSSON (Flygtekniska Forsöksanstalten, Bromma, Sweden), and Y. C.-J. SEDIN (Saab-Scania, AB, Linköping, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 770-778. refs

A method using local slot boundary conditions has been applied for design and analysis of optimal slots giving minimum or very low wall interference in transonic wind tunnels with slotted walls. The basically inviscid mathematical model was corrected for viscous effects. The considered test section is rectangular and the flow

inside was computed using the nonlinear transonic small perturbation equation. Separate equations were solved for each slot. Encouraging results have been obtained for a relatively large wing-body model at two Mach numbers at two angles of attack. The set of slot shapes designed for these flight conditions were computationally verified to give low interference on the test model. The inverse design mode gave the necessary slot geometries and the plenum pressure. Direct mode calculations then gave the wall interference and in principle also the mass flow setting of the tunnel. Author

A86-49060#

ANALYSIS OF WIND TUNNEL CORRECTIONS FOR HALF-MODEL TESTS OF A TRANSPORT AIRCRAFT USING A DOUBLET PANEL METHOD

M. J. MOKRY, J. R. DIGNEY (National Aeronautical Establishment, Ottawa, Canada), and R. J. D. POOLE (De Havilland Aircraft of Canada, Ltd., Downsview) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 779-785. Research supported by the De Havilland Aircraft of Canada, Ltd., and National Research Council of Canada. refs

A correction method is described for half model tests using wall pressures measured by longitudinal static pressure tubes, and measured model forces. The Dirichlet problem for the Mach number correction is solved by a doublet panel method and the flow angle corrections are obtained from the irrotational flow conditions. The method is applied to a transport aircraft half-model tested in the NAE perforated wall wind tunnel. The Mach number and angle of attack corrections are presented as contour plots, allowing analysis of the effects of wall induced gradients. In the range of normal operating lift coefficients, the corrected drag polar is shown to correlate well with data from full-model wind tunnel tests and from the flight test aircraft. Author

A86-49061#

AEROACOUSTICS AT THE GERMAN-DUTCH WIND TUNNEL

H. H. HELLER, W. R. SPLETTSTOESSER, W. M. DOBRZYNSKI, and K.-J. SCHULTZ (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 786-800. refs

The German-Dutch Wind Tunnel ('DNW') in the Netherlands has been fully operational for about four years. When used in its open test section configuration it represents probably the best aeroacoustic research facility in existence, allowing large scale or even full scale testing of aircraft-related noise generators. This paper attempts to illustrate the unique technical capabilities of the DNW on the example of two major recent research projects, dealing, respectively, with the noise of General Aviation aircraft propellers and helicopter main rotors. For these two projects, background and technical problem-areas are outlined, the special experimental set-ups as required in a facility of such physically large size, the data acquisition and reduction procedures, and the implications of the wind-tunnel-test-obtained results for aeroacoustics are delineated. Also, the preparations for a planned near-term model helicopter main-rotor/tail-rotor aeroacoustic interaction experiment are discussed. Finally, an outlook is given on the DNW-potential for future high quality aeroacoustic research. Author

A86-49075#

THE F2 WIND TUNNEL OF THE FAUGA-MAUZAC TEST CENTER

J. M. CHRISTOPHE (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 923-933. refs (ONERA, TP NO. 1986-104)

The new subsonic research wind tunnel F2 at the Fauga-Mauzac Center and its capabilities are described. The main characteristics of the F2 are reviewed, and the laser velocimeter system of the

09 RESEARCH AND SUPPORT FACILITIES (AIR)

tunnel, which can investigate a volume of 1.4 m x 1.8 m x 4.25 m with displacements of + or 0.25 m axial, + or - 0.3 m lateral, and + or - 0.5 m vertical, is described. The main results of the aerodynamic calibration are summarized, and some typical test results are discussed. These include tests using a two-dimensional cylinder, elliptical body tests, a fighter wake study, and a study of a flat delta wing. The very good flow symmetry obtained during all the tests confirms the quality of the flow in the tunnel. C.D.

A86-49143

EXPERIENCE WITH STRESS ANALYSIS DURING AIRFRAME FATIGUE TESTS [ZKUSENOSTI Z NAPETOVE ANALYZE PRI UNAVOVYCH ZKOUSKACH DRAKU LETADEL]

J. FIALA, J. HODR, and J. VRHEL Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1986, p. 107-111. In Czech.

The contribution deals with the ascertainment of the stressed state in aircraft structures and their parts during fatigue tests. Described are the instrumentation and software as well as the measuring methods. Further, specific examples are given of results obtained from strain gauge measurements and of application of brittle varnishes. Author

A86-49683#

WIND TUNNELS BATTLE THE NUMBER-CRUNCHERS

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Aug. 1986, p. 42-46.

An evaluation of the recent development history of competing computational fluid dynamics (CFD) and advanced wind tunnel testing methods notes that the most refined CFD efforts revealed mathematical modeling shortcomings that could only be corrected through renewed and more sophisticated efforts in wind tunnel test measurement and data collection methods. The techniques whose development has been thus stimulated encompass cryogenic wind tunnels for transonic research, laser velocimetry, high surface finish metallic models, coaxial thermocouples, and the incorporation of highly realistic model engines. O.C.

N86-31596# Naval Postgraduate School, Monterey, Calif. **DESIGN OF A VERTICAL THRUST STAND FOR A REMOTELY PILOTTED MODEL HELICOPTER M.S. Thesis**

T. J. URDA Mar. 1986 42 p
(AD-A167811) Avail: NTIS HC A03/MF A01 CSCL 14B

This paper discusses the necessary functional characteristics for the design of a test stand to measure the vertical thrust of a remotely piloted model helicopter as a function of power output, in different degrees of ground effect. A number of potential design choices are presented along with possible instrumentation schemes to obtain both the power output and the lifting force generated by the Heli-Star model helicopter equipped with a Gold Cup HP.61 engine. Included are the results of preliminary validation testing of the test stand design chosen and a discussion of the methods used to eliminate or control vibrations which hampered the utility of the test stand. Recommendations for possible future modifications are also included. GRA

N86-31602# Federal Aviation Administration, Washington, D.C. Office of Environment and Energy.

AIRPORT NOISE CONTROL STRATEGIES

P. A. CLINE May 1986 126 p
(AD-A167977; FAA-EE-86-02) Avail: NTIS HC A07/MF A01 CSCL 20A

The Federal Aviation Administration's (FAA) Airport Noise Control Strategies Data File contains a comprehensive listing of airport noise control actions. The information contained in this data file is an updated version of the June 1983 Airport Noise Control Strategies report. Originally, the data were collected from the Environmental Data Bank of March 1979, the National Business Aircraft Association and the Aircraft Operators Council International. Additional data were garnered from the FAA Airport Facility Directory. For this version, the FAA regional offices reviewed the latest information and made appropriate changes. Thirty-seven categories of noise control actions have been identified and are

in use, singly or in combination, by approximately 400 airports.

GRA

N86-31604# VDO-Luftfahrtgeraete Werk Adolf Schindling G.m.b.H., Frankfurt (West Germany). Bereich Luftfahrt. **STUDIES FOR THE APPLICATION OF A FLEXIBLE WEIGHT AND BALANCE (W/B) MEASURING FACILITY FOR COMMERCIAL AIRCRAFT Final Report, Jun. 1984**

H. W. FISCHER Bonn Bundesministerium fuer Forschung und Technologie Dec. 1985 73 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie (BMFT-FB-W-85-029; ISSN-0170-1339; ETN-86-97471) Avail: NTIS HC A04/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 15.50

A weight and balance measuring facility incorporating shear stress sensors was developed and studied as regards accuracy, stability and applicability. The sensor system measures shear stress on the landing gear frame or on the nose landing gear tire axis. The construction, efficiency, maneuverability, and interfaces on the shear stress system are described. The causes of hysteresis in the measuring systems at the nose landing gear are experimentally investigated. The facility can be applied to series measurement. ESA

N86-32447* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SIMULATOR SCENE DISPLAY EVALUATION DEVICE Patent
R. F. HAINES, inventor (to NASA) 12 Aug. 1986 8 p Filed 22 Dec. 1983 Supersedes N84-16221 (22 - 07, p 960)
(NASA-CASE-ARC-11504-1; US-PATENT-4,605,303;
US-PATENT-APPL-SN-565481; US-PATENT-CLASS-356-73)
Avail: US Patent and Trademark Office CSCL 14B

An apparatus for aligning and calibrating scene displays in an aircraft simulator has a base on which all of the instruments for the aligning and calibrating are mounted. Laser directs beam at double right prism which is attached to pivoting support on base. The pivot point of the prism is located at the design eye point (DEP) of simulator during the aligning and calibrating. The objective lens in the base is movable on a track to follow the laser beam at different angles within the field of vision at the DEP. An eyepiece and a precision diopter are movable into a position behind the prism during the scene evaluation. A photometer or illuminometer is pivotable about the pivot into and out of position behind the eyepiece.

Official Gazette of the U.S. Patent and Trademark Office

N86-32448 Carville Ltd., Dorking (England).

AN IMPROVED OPTICAL VIEWING SYSTEM FOR A FLIGHT SIMULATOR

K. J. GIBSON and I. M. WELLS Aug. 1985 26 p
(Contract MOD-85A/431)
(MS-8025; BR96992; ETN-86-96555) Avail: Issuing Activity

A large compound lens to be used to collimate the scene displayed on a 26in diagonal television monitor was developed. The development was undertaken for a flight simulator but is applicable in other areas whenever collimation of a relatively wide angle scene is required. A field of view of nominally 47 deg horizontally by 36 deg vertically is available with an eye relief of 560mm (22in). The prototype lens shows the design to be totally free of any chromatic aberrations. Geometric distortions are acceptable for most applications. ESA

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A86-47602**A ROUND-UP ON CFRP**

G. NIEDERSTADT (DFVLR, Brunswick, West Germany) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messegesellschaft mbH, 1985, 20 p.

The properties of CFRPs and components are discussed. Data on specific strength and specific moduli for many commercially available carbon fibers for advanced composite applications are presented, together with data for fiber-reinforced materials. Consideration is given to tests carried out to select fiber and resin responses to optimization of the composite materials and, in particular, to the requirements to be met for minimal fracture elongation. The implementation of advanced composites on aircraft structures is discussed together with problems of control and maintenance. I.S.

A86-47603* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COMPOSITES IN TODAY'S AND TOMORROW'S U.S. AIRLINERS

H. L. BOHON (NASA, Langley Research Center, Hampton, VA) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messegesellschaft mbH, 1985, 33 p. refs

The research conducted by NASA's Aircraft Energy Efficiency Composites program in developing essential technologies for the efficient utilization of composites in the airframe structures of transport aircraft is described. Current activities, present state-of-the-art, production trends in the U.S., and the outlook for major use of composites in primary structures are examined. Special attention is given to application of composites in transport wing and fuselage structures. The projections for the Advanced Tactical Fighter of the late eighties suggest application of composites in the airframe structures to the extent of 50 percent, an all-composite transport could become a reality in the mid-nineties. I.S.

A86-47715**ADHESIVE SELECTION FROM THE USER'S VIEWPOINT**

E. C. MILLARD (Rohr Industries, Inc., Riverside, CA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 89-97.

A guide is presented for the potential user of adhesives for bonded aluminum structures, indicating how to choose among available adhesives and pitfalls to avoid. Three main considerations - cure parameters, adhesive form, and cost can determine the basic type of adhesive to be used. Cure parameters are noted for liquid systems, the foam adhesives that expand and cure at elevated temperatures, bulk or hot-melt systems, and film adhesives. Service requirements (temperature range and duration of temperature stressing, environmental resistance, mechanical properties, durability, and handleability) must be considered in making a choice. Surface preparation, primer, and adhesive must all be tested. Also covered are preparation of tests specimens, conducting the tests, storage of the adhesives, and problems encountered in practice. D.H.

N86-32451# Office National d'Etudes et de Recherches Aeronautiques, Paris (France). Direction de la Physique Generale. **MICROPHONE PROBE TESTS IN THE S3CH WIND TUNNEL FOR TRANSONIC PROPELLER MEASUREMENTS IN S1MA [ESSAI DE SONDES MICROPHONIQUES DANS LA SOUFFLERIE S3CH EN VUE DES MESURES SUR HELICE TRANSSONIQUE DANS S1MA]**

H. GOUNET and J. LAMBOURION Feb. 1985 35 p In FRENCH Sponsored by Direction des Recherches Etudes et Techniques (ONERA-RT-19/3463-AYP; ETN-86-97873) Avail: NTIS HC A03/MF A01

Acoustic measurements were carried out in order to test modifications of radial microphone wind tunnel sensors and to verify the influence of the model support. The tests were made at Mach numbers from 0.3 to 0.85 and several configurations of the distribution of acoustic sensors. Spectra up to 5000 Hz were obtained. It is shown that 1000 Hz, which is the fundamental transonic propeller frequency, is well detected by the system. No interference due to the model support is found. ESA

ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A86-47679#**OPTIMAL DESCENDING, HYPERSONIC TURN TO HEADING**

G. R. EISLER and D. G. HULL (Texas, University, Austin) IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 248-252. refs (AIAA PAPER 86-2134)

Approximations are made to the point-mass equations of motion for flight within the atmosphere. Optimal controls are formulated for a reentry vehicle to execute a maximum-terminal-velocity turn to a specified heading while executing steep, descent trajectories. A Newton scheme is used to repetitively solve a nonlinear algebraic system for two parameters in the control equations to provide the on-line guidance. Trajectory comparisons from a continuous solution of the optimal control problem, pure numerical optimization, and simulation of sample-data guidance show good agreement, if the atmospheric model is accurate. Author

A86-47902#**DIRECT TRAJECTORY OPTIMIZATION USING NONLINEAR PROGRAMMING AND COLLOCATION**

C. R. HARGRAVES and S. W. PARIS (Boeing Aerospace Co., Seattle, WA) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 3-12. refs (Contract F33615-85-C-3009) (AIAA PAPER 86-2000)

An algorithm for the direct numerical solution of an optimal control problem is given. The presented method employs cubic polynomials to represent state variables, linearly interpolates control variables and uses collocation to satisfy the differential equations. This representation transforms the optimal control problem to a mathematical programming problem which is solved by sequential quadratic programming. The method is easy to program for a very general trajectory optimization problem and is shown to be very efficient for several sample problems. Results are compared with solutions obtained with other methods. Author

A86-47717

ELEVATED-TEMPERATURE-RESISTANT ADHESIVES

E. C. MILLARD (Rohr Industries, Inc., Riverside, CA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 127-140.

Elevated-temperature-resistant adhesives designed to perform between 300 and 650 F (149 and 343 C) are discussed. Considerable work has been done in recent years to eliminate some problems such as short life at elevated temperatures or difficulties in processing and handleability. It is important to develop an experience matrix showing the relationship between time and temperature and then add a third parameter, performance under sustained stress. Testing until the required exposure time has elapsed or specimen failure occurs is expensive and monopolizes laboratory equipment for long periods, so it is very important to conduct a thorough investigation of basic properties and determine that the system under test has a good chance of meeting engineering requirements. This can be helped by working in full cooperation with the adhesive supplier and carefully assessing the chemical structure of the adhesive polymers and curing systems. Characteristics of unmodified epoxy, epoxy phenolic, nitrile phenolics, and polyimide are discussed along with adhesive forms, carriers, and compatibility with primers. Tensile shear strengths of various adhesives are tabulated and shelf-life and out-time considerations and processibility are discussed. D.H.

A86-47720

CHEMICAL ANALYSIS FOR CONTROL

D. K. HADAD (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 199-226. refs

It is noted that the fundamental requirement for producing high-quality, reliable finished parts with polymer systems is to start with controlled and consistent materials. Years of qualification tests are run on adhesives as well as other resin matrices to establish a statistical base for design analysis and long-term environmental stability. Generally, tests have been run to determine mechanical properties, gel times, and flow tests for lot-to-lot comparisons, but such tests cannot always detect chemical changes which can affect long-term performance. If chemical quality testing precedes mechanical property testing, much labor can be saved, which can make the procedures highly cost-effective. Instrumental techniques include: infrared spectroscopy, liquid chromatography, thin-layer chromatography, thermal analysis, and dynamic dielectric analysis. Carbon-13 and proton nuclear magnetic resonance spectroscopy as well as some wet chemical test methods are also used. D.H.

A86-48097

ANALYSIS OF THE COSTS AND WEIGHT EFFECTS OF CFK ON AIR TRANSPORT STRUCTURE [ANALYSE DER KOSTEN-UND GEWICHTSEINFLUESSE VON CFK AUF LUFTFAHRTSTRUKTUREN]

H. AREND (Berlin, Technische Universitaet, West Germany) IN: Arbeitsgemeinschaft Verstaerkte Kunststoffe, Open Annual Meeting, 20th - International Meeting on Reinforced Plastics, Freudenstadt, West Germany, October 1-3, 1985, Reports. Frankfurt am Main, West Germany, Arbeitsgemeinschaft Verstaerkte Kunststoffe, 1986, p. 41-1 to 41-7. In German. refs

An analysis of the literature is used to derive mean values for the cost and weight reductions attainable by using CFK components in the most important structural subassemblies of aircraft instead of conventional aluminum components. The prices of raw materials and the effect of materials costs on the operating costs of commercial aircraft are taken into account. Significant cost and weight savings are found to be achievable by the use of CFK. C.D.

A86-48123#

THERMAL DECOMPOSITION OF AIRCRAFT FUEL

P. J. MARTENEY and L. J. SPADACCINI (United Technologies Research Center, East Hartford, CT) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p. refs
(Contract N00140-83-C-9119)
(ASME PAPER 86-GT-36)

A test program has been conducted to determine the thermal stability and heat transfer characteristics of JP-5 and several other kerosene-type fuels which vary in composition and tendency to form deposits. Tests were conducted in small-diameter, resistively heated tubes at typical aircraft engine operating conditions. A detailed mapping of the thermal decomposition characteristics of JP-5 was performed to evaluate the importance of key environmental factors - such as temperature, pressure, flowrate, and test duration - and to establish a data base for estimating the relative performance of new fuels. Tests were conducted over the temperature range 425 to 870 K for durations up to 32 hr. Fuel deposition rates varied among fuels, and the relationship between the 'breakpoint temperature' (determined according to ASTM D3241) and the rate of fuel deposition was investigated.

Author

A86-48159#

THERMAL STABILITY CONCERNS OF NAVY AVIATION FUEL

C. A. MOSES (Southwest Research Institute, San Antonio, TX), P. A. KARPOVICH (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ), and M. W. SHAYESON ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs
(Contract N00140-80-C-2269)
(ASME PAPER 86-GT-94)

The U.S. Navy's concerns about the thermal stability of aviation fuel stem from a combination of increased performance requirements of engines and potential degradation in fuel quality. The results of recent atomizer fouling tests with hot fuel are presented. These are combined with similar results from Air Force programs and analyzed with respect to the impact on engine performance and reliability.

Author

A86-48210#

CONICAL GRID PLATE FLAME STABILIZERS - STABILITY AND EMISSIONS FOR LIQUID FUELS

A. F. ALI and G. E. ANDREWS (Leeds University, England) IN: ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 9 p. refs
(Contract SERC-GR/B/92812; SERC-GR/D/25620)
(ASME PAPER 86-GT-156)

Flame Stability and Emission results are presented for a jet shear layer primary zone design consisting of a 90-deg conical flame stabilizer with a central annular vaporizer fuel injection system feeding an array of air jets. The performance with kerosene and gas oil fuels is compared with previous work with propane. The influence of the primary zone residence time or Mach number is shown to be much more significant for liquid fuels than for propane. An acceptable combustion efficiency was only achieved at a Mach number of 0.03, corresponding to 60 percent of the combustion air in the primary zone, provided that the pressure loss was maintained, as the Mach number was reduced, by using a stabilizer of higher blockage. NO(x) emissions with kerosene were compatible with those for propane, but for gas oil there was a significant increase in NO(x).

Author

A86-48216#

COMBUSTION GAS PROPERTIES. II - PREDICTION OF PARTIAL PRESSURES OF CO₂ AND H₂O IN COMBUSTION GASES OF AVIATION AND DIESEL FUELS

OE. L. GUELDER (National Research Council of Canada, Div. of Mechanical Engineering, Ottawa) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 5 p. refs

(ASME PAPER 86-GT-163)

Empirical formulas are presented by means of which the partial pressures of CO₂ and H₂O in the combustion gases of aviation fuel-air and diesel fuel-air systems can be calculated as functions of pressure, temperature, equivalence ratio, and hydrogen-to-carbon atomic ratio of the fuel. The formulas have been developed by fitting the data from a detailed chemical equilibrium code to a functional expression. Comparisons of the results from the proposed formulas with the results obtained from a chemical equilibrium code have shown that the mean absolute error in predicted partial pressures is around 0.8 percent. These formulas provide a very fast and easy means of predicting partial pressures of CO₂ and H₂O as compared to equilibrium calculations, and they are also applicable to gasoline residual fuels, and pure alkanes and aromatics as well as aviation and diesel fuels.

Author

A86-48285#

IMPACT OF HIGHER FREEZE POINT FUELS ON NAVAL AIRCRAFT OPERATIONS

R. A. KAMIN (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) and P. M. MCCONNELL (Boeing Military Airplane Co., Seattle, WA) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p. refs (ASME PAPER 86-GT-262)

Refinery process studies have indicated that the relaxation of the JP-5 freeze-point specification is a viable means of increasing jet fuel availability. The Naval Air Propulsion Center is investigating the impact of higher freeze point fuels on naval aircraft operations. Six fuels, with freeze points ranging from -55 F to +10 F, were tested in two instrumented external fuel tanks. Thirty hours of flight test and one hundred hours of wind tunnel test data have been accumulated. This information is being used in conjunction with laboratory and bench-scale test data to support the development of a three-dimensional computer code. This code will predict fuel cool-down and hold-up (unpumpable frozen fuel) for any fuel tank geometry during a mission. Initial results indicate that the current JP-5 freeze-point specification of -51 F is conservative and could be safely relaxed.

Author

A86-49020#

MATERIALS IN AEROSPACE - CAN THE EMERGING THERMOPLASTICS MEET THE CHALLENGE?

C. K. HALL (British Aerospace, PLC, Army Weapons Div., Stevenage, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 397-402. refs

The types and properties of thermoplastics are discussed, and a comparison with thermosets with respect to their applicability to radomes, aircraft structures, circuit boards, and missile body airframes, is presented. Thermoplastics can be used as pure resins with no reinforcement to produce engineering components, and their ductility and relatively reduced cost production rates compare favorably with those of thermosets, though present knowledge of their performance is still limited. Prediction of fiber orientation for short fiber reinforced composites is necessary for highly loaded applications such as missile bodies.

R.R.

A86-49021#

ADVANCED POLYMER COMPOSITES FOR HIGH TEMPERATURE APPLICATIONS

D. WILSON (British Petroleum Co., PLC, Research Centre, Sunbury, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 402a-402p. refs

Advanced composites are finding widespread use throughout the aerospace industry. However, conventional epoxy based systems are limited to continuous use temperatures around 130 C. There are many applications requiring continuous use temperatures substantially in excess of this, and aero-engines and missiles are prime examples. A considerable amount of effort has been directed towards the synthesis of high temperature resins. Systems are now available that have the capability of performing for thousands of hours at 200 C, for hundreds of hours at 300 C, and for seconds at temperatures as high as 760 C. In developing advanced composites for high temperature applications, attention must not only be paid to the matrix resin but to the fiber and fiber-resin interface as well. Also, in the production of composite components, adhesive bonding, with high temperature adhesives, is also desirable. This paper will review the present state of high temperature composite technology with reference to matrix resins, fibers and adhesives. Applications and future needs and markets will also be discussed.

Author

A86-49077#

SINGLE CRYSTAL SUPERALLOYS FOR TURBINE BLADES IN ADVANCED AIRCRAFT ENGINES

T. KHAN and P. CARON (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 944-950. refs (ONERA, TP NO. 1986-102)

A number of high strength single crystal superalloys tailored for the casting of complex shaped blades and vanes have been developed in USA, Europe and Japan. Some of the recently developed European alloys also offer the advantage of relatively low densities allowing lower disc stresses. The stress rupture properties of selected single crystal superalloys are compared. The heat treatments are shown to play a crucial role in improving the creep resistance of these alloys. The use of high temperature gradients during single crystal solidification is shown to considerably improve the fatigue strength of single crystal alloys due to reduced casting porosity. HIP'ing is presented as an alternative technique for improving the fatigue resistance of low gradient processed industrial single crystals.

Author

A86-49963

THE EFFECT OF THE MONOETHERS OF DICARBOXYLIC ACIDS ON THE ANTIWEAR PROPERTIES OF JET FUELS [VLIANIE MONOEFIROV DIKARBONOVYKH KISLOT NA PROTIVOIZNOSNYE SVOISTVA REAKTIVNYKH TOPLIV]

A. S. KISLENKO, I. F. KRYLOV, G. I. SOKOLOVA, V. P. SEREGIN, and G. B. SKOVORODIN (Moskovskii Institut Neftekhimicheskoi i Gazovoi Promyshlenosti, Moscow, USSR) Khimiia i Tekhnologia Topliv i Masel (ISSN 0023-1169), no. 6, 1986, p. 16-18. In Russian. refs

Experimental data are presented on the effect of the addition of synthetic monoethers of dicarboxylic acids in amounts of 0.004-0.07 percent (by mass) on the antiwear properties of hydrorefined jet fuels. It is found that the antiwear effect of these additives is largely determined by their structure. In particular, the effectiveness of the monoethers as antiwear additives increases with the decreasing number of methylene groups contained between the functional groups of the dicarboxylic acids and with the decreasing length of the alcohol hydrocarbon radical.

A86-49964

AN ANALYSIS OF THE QUALITY OF AVIATION LUBRICANTS BY LIQUID AND GAS-LIQUID CHROMATOGRAPHY [ANALIZ KACHESTVA AVIATIONNYKH SMACHOCHNYKH MASEL METODAMI ZHIDKOSTNOI I GAZOZHIDKOSTNOI KROMATOGRAFI]

G. G. KHOLOSTOVA, V. N. BAKUNIN, and G. S. SHIMONAEV
Khimia i Tekhnologii Topliv i Masei (ISSN 0023-1169), no. 6, 1986, p. 24-26. In Russian. refs

The principal techniques of the chromatographic analysis of the quality of oils for aircraft gas turbine engines are examined, and some characteristics of the aging behavior of aviation oils are discussed. In particular, experimental data are presented for a commercial-grade ether of pentaerythrite and C5-C9 synthetic fatty acids which is used as the base of a series of aviation oils. V.L.

A86-50122

OPTIMIZATION OF COMPOSITE STRUCTURES BY CONTROLLED INSERTION OR DELETION OF DIVERSE FIBER TYPES

J. L. MCLARTY (Fiber Composites, Inc., Port Ludlow, WA) IN: International Symposium on Composite Materials and Structures, Beijing, People's Republic of China, June 10-13, 1986, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1986, p. 301-306.

Filament-winding fabrication techniques for GFRP, CFRP, and hybrid composite structures incorporating controlled insertion or deletion of fibers (IDF) are discussed and illustrated. The advantages of IDF, permitting the designer to optimize the component in terms of performance, size, and weight by varying the cross-section area and shape of the fiber bands and the volume fractions of fibers of different types, are reviewed; the IDF design of an aircraft aileron using Kevlar, S-glass, and carbon fibers in an epoxy matrix is explained; production machines capable of implementing IDF in the filament-winding process are described; and the ability of IDF technology to manufacture complex shapes such as spheres, thin panels, aircraft fuselages with window and door openings, and vehicle bodies is considered. IDF fabrication of the aileron is shown to permit savings of 25 percent in weight and 15 percent in labor costs compared with a constant-cross-section nonhybrid composite. T.K.

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A86-47292

INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY, 10TH, AND CONGRES INTERNATIONAL AERONAUTIQUE, 17TH, PARIS, FRANCE, JUNE 10-13, 1985, PROCEEDINGS

Conference and Congress organized by the Association Aeronautique et Astronautique de France; Sponsored by the Delegation Generale pour l'Armement, CNES, U.S. Army, et al. Les Ulis, France, Les Editions de Physique, 1985, 527 p. For individual items see A86-47293 to A86-47338.

The conference presents papers on statistical data and standards, coupling and indirect effects, meteorology and thunderstorm studies, lightning simulators, fuel ignition hazards, the phenomenology and characterization of lightning, susceptibility and protection of avionics, ground systems protection, lightning locators, aircraft systems protection, structures and materials, electrostatics, and spacecraft protection against static electricity. Particular attention is given to a comparison of published HEMP

and natural lightning on the surface of an aircraft, electromagnetic interaction of external impulse fields with aircraft, of thunderstorm currents and lightning charges at the NASA Kennedy Space Center, the design of a fast risetime lightning generator, lightning simulation tests in FAA CV-580 lightning research aircraft, and the energy requirements of an aircraft triggered discharge. Papers are also presented on aircraft lightning attachment at low altitudes, a new form of transient suppressor, a proving ground for lightning research, and a spacecraft materials test in a continuous, broad energy-spectrum electron beam. K.K.

A86-47296

INDUCED SURFACE CURRENTS AND FIELDS ON A CONDUCTING BODY BY A LIGHTNING STRIKE (FREQUENCY DOMAIN)

E. GRORUD and M. SOIRON (Laboratoire Central des Telecommunications, Velizy-Villacoublay, France) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 21-24.

A method is presented for simulating the electromagnetic excitation of a conducting body of arbitrary shape by a direct lightning strike. The Electric Field Integral Equation (E.F.I.E.) is solved in the frequency domain by the method of moments. The modeling of the conducting body uses planar triangular patches and is done automatically by a mesh generation procedure from a given set of data points. For direct strike simulation, the lightning attachment points are modeled by 'wire-surface' junction type triangles. Some time domain results are obtained on an aircraft using an inverse Fourier Transform (FFT). Author

A86-47312

HIGH VOLTAGE LABORATORY TESTS AND LIGHTNING PHENOMENA

B. HUTZLER, G. RIQUEL, and J.-P. RIU (Electricite de France, Laboratoires d'Essais a Haute Tension, Moret-sur-Loing) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 191-196. refs

Attention is given to the similarities and differences which exist between the laboratory long spark and an actual lightning stroke. The feasibility of using simulation to evaluate the consequences of natural lightning on aircraft and grounded structures is assessed. Laboratory test facilities and measuring techniques are reviewed, the main features of the long spark are presented, and the influence rendered by experimental conditions is discussed. The final stage of the discharge is described as it relates to the striking of grounded structures; discharge characteristics upon interaction with a free potential electrode inside the gap are given. It is concluded that the study of RF signals radiated by a laboratory spark could lead to a better understanding of those emitted by natural lightning. It is noted that the striking of grounded structures is satisfactorily reproduced by laboratory tests. K.K.

A86-47315

THE ENERGY REQUIREMENTS OF AN AIRCRAFT TRIGGERED DISCHARGE

J. A. BICKNELL and R. W. SHELTON (University of Manchester Institute of Science and Technology, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 217-221. refs (Contract AF-AFOSR-83-0083)

The corona produced at aircraft surfaces requires an energy input before the corona can develop into a high current discharge and, thus, a possible lightning stroke. This energy must be drawn from the space charge field of the thundercloud and, since this is of low density, the unique propagation characteristics of positive corona streamers may be important. Estimates of the energy made available by the propagation are compared with laboratory

measurements of the minimum energy input required to trigger a breakdown. The comparison indicates a minimum streamer range for breakdown of several tens of meters. Also estimated is the energy released as a consequence of streamer-hydrometer interactions; this is shown to be significant so that breakdown could depend upon the precipitation rate within the cloud. Inhibiting streamer production may therefore provide an aircraft with a degree of corona protection.

Author

A86-47329

RING DISCHARGE ON THE BACKSURFACE OF A COMPOSITE SKIN WITH OHMIC ANISOTROPY IN RESPONSE TO FRONTAL HIGH CURRENT INJECTION

T. S. LEE (Minnesota, University, Minneapolis) and J. D. ROBB (Lightning and Transients Research Institute, St. Paul, MN) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings. Les Ulis, France, Les Editions de Physique, 1985, p. 377-382. USAF-Navy-supported research.

The ring discharge hazard to a carbon-reinforced-composites fuel tank skin under lightning strike conditions is investigated. A model of anisotropy in electric conductivity is adopted whereby longitudinal conductivity and transverse conductivity are considered separately. It is concluded that the current flow pattern contains a stagnation-dominated near-field region and a geometry-dominated far-field decaying region. While this pattern is unaltered by anisotropy in conductivity, the accompanying nonlinear electrical field pattern is greatly distorted. It is noted that conclusions applicable to the ignition hazard which were derived from the model of a uniform scalar conductivity for the skin still remain intact.

K.K.

A86-47525

SUPPLEMENTAL INSPECTIONS OF AGING AIRCRAFT

D. J. HAGEMAIER, P. R. ABELKIS (Douglas Aircraft Co., Long Beach, CA), and M. B. HARMON. Materials Evaluation (ISSN 0025-5327), vol. 44, July 1986, p. 989-997. refs

The Federal Aviation Administration (USA) and the Civil Aviation Authority (Great Britain) have instructed manufacturers to prepare supplemental inspection documents (SIDs) for aging aircraft. This article describes the Douglas Aircraft Company approach to developing an SID program to provide for safe operation of DC-8, DC-9, and DC-10 commercial transport aircraft. Principal structural elements (PSEs) are selected for damage-tolerance analysis. Where normal maintenance practices do not provide adequate coverage, nondestructive inspection (NDI) procedures are developed for each PSE. This article describes the inspection procedure and how detectable flaw sizes are established. Factors affecting inspection reliability are discussed. Implementation of the inspection program is provided by inspection criteria concepts. These concepts include a fleet sampling program that helps protect aging aircraft by use of sophisticated methods of detecting cracks. The inspection criteria approaches combine damage-tolerance with statistical-sampling concepts.

Author

A86-47595

ANALYTICAL APPLICATIONS IN THE ARMY OIL ANALYSIS PROGRAM

C. M. BROWN and L. E. BOLEY (U.S. Army, Materiel Command, Lexington, KY) IN: Materials characterization for systems performance and reliability; Proceedings of the Thirty-first Sagamore Army Materials Research Conference, Lake Luzerne, NY, August 13-17, 1984. New York, Plenum Press, 1986, p. 403-412.

Tests and instruments used by the U.S. Army to determine the quality of soil being used in military equipment are discussed. Viscosity determination, the crack test, the blotter spot test, and testing for insolubles are briefly described along with ferrographic analysis. The advantages of ultrafine filtration combined with a full-flow chip detector superior to those now in use are summarized. Methods of taking oil samples from equipment, the intervals at which samples are taken, and the analytical procedure are reviewed. The analysis of used oils is addressed, and the

advantages of modernizing the testing by using computers are discussed. New instrumentation being considered is described, including the ferrograph, infrared spectrometer, water analyzer, flash point tester, portable wear-metal analyzer, and portable physical property test monitor.

C.D.

A86-47613

MODERN CRACK DETECTION METHODS - THE USE OF LOW FREQUENCY EDDY CURRENTS TO ASSIST STRUCTURAL INTEGRITY AUDITING

B. A. MANNERS (British Aerospace, PLC, Aircraft Group, Weybridge, England) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messgesellschaft mbH, 1985, 9 p.

Two areas in the 748 fuselage where the use of eddy current NDT techniques are most effective are the window skin cutouts and the skin horizontal lap joints. The nature of the structural integrity problems in these areas and the resulting inspection solutions are discussed. Surface breaking defects in the window skin as small as 0.06 in. could be detected, using high frequency eddy current with a Novalec 96C nonferrous absolute coil probe, as opposed to 0.50-in.-long defects detectable by visual inspection. The inspection time for the complete fuselage was 2 h. For the fuselage skin lap joints, the use of a low frequency eddy current technique with an Elotest B2 instrument and a special probe, which could be slid continuously along the rivet row, was found to be most effective. The whole of the lap joints, both horizontal and circumferential, could be inspected in 10 hrs.

I.S.

A86-47719

ENVIRONMENTAL-DURABILITY TESTING

J. A. MARCEAU (Boeing Commercial Airplane Co., Seattle, WA) and E. W. THRALL (Douglas Aircraft Co., Long Beach, CA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 177-197. refs

Procedures are indicated for a manufacturer of bonded assemblies to follow when a new surface process or a new generation of adhesives is introduced. Previous experience may not be applicable, so new tests are required. It is important to ask the question 'Is it suitable for practical use?' rather than the common question 'Does it meet the requirements of the specification?'. Destructive testing of specimens must be carried out to indicate the quality of adhesive and pretreatment combination used to bond the test specimens, not just the surface pretreatment. A large number of test specimens (T-peel and lap shear) with the same pretreatment were tested after different environmental baths. The results showed the uniformity of peel strength values for a given adhesive in contrast to lap shear tests where shear results can vary over a large range for the same adhesive system. This says that peeling tests are most selective for measuring surface treatment quality differences. A series of Boeing tests has also confirmed that wedge crack tests, which also put adhesive in tension as do the peeling tests, will show up small differences in surface treatment quality. Specific test specimens must be used to verify that the production processing is giving the proper durability and strength results for each production run. Shannon et al. (1978) is cited as an excellent reference summarizing environmental testing.

D.H.

A86-47721

COATINGS

S. NAKAHARA (Douglas Aircraft Co., Long Beach, CA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 227-240. refs

Corrosion of aluminum occurs in various forms, it is noted, with most being electrochemical in nature. Corrosion characteristics are generally well-known and recognized. The forms of corrosion usually found in bonded joints, trimmed edges, and at attachment areas can be identified as surface, crevice, pitting, exfoliation, and/or filiform-type corrosion. To protect bare areas that result during fabrication, the use of a protective coating system is

necessary. Based on laboratory and historic in-service data, the following systems applied over the adhesive primer will be most effective in inhibiting corrosion: for interior surfaces of aircraft, above the floor line, use amine-cured epoxy primer; below the floor line, use amine-cured epoxy primer and top coat. For exterior surfaces, use the epoxy polyamide-cured primer and aliphatic urethane top coat or the modified epoxy primer and flexible aliphatic urethane top coat. The primary advantage of the two-primer (wash primer and urethane primer top coat system) is that it provides easy strippability. D.H.

A86-47722**STRUCTURAL ANALYSIS OF ADHESIVE-BONDED JOINTS**

L. J. HART-SMITH (Douglas Aircraft Co., Long Beach, CA) and E. W. THRALL (Aeronautical Structures, Point Arena, CA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 241-321. refs

The end product of the adhesive-bonding process - the bonded joint - is examined. A basic criterion that must be accepted by designers is the fact that the weak link in a bonded joint should never be the adhesive. The overlap length and other metal details, such as tapered edges, will prevent adhesive failure from occurring before the metal parts fail. It is important for designers to make primary load transfers with the adhesive in shear; if the adhesive must be in tension, careful attention to the metal details is required to eliminate 'hard' spots in the joint. Types of joint considered are: double-strap bonded joints, single-lap bonded skin splices, and skin-to-stiffener bonded joints. Elastic-plastic analysis of bonded discontinuous members is examined in detail, and the cracking of pressurized-bonded stiffened fuselage shells is considered. D.H.

A86-47725**ADHESIVE-BONDED ALUMINUM STRUCTURE REPAIR**

M. H. KUPERMAN (United Airlines Maintenance Operations Center, San Francisco, CA) and R. E. HORTON (Boeing Commercial Airplane Co., Seattle, WA) IN: Adhesive bonding of aluminum alloys. New York, Marcel Dekker, Inc., 1985, p. 425-493. refs

The in-service repair of adhesive-bonded aluminum aircraft structures is discussed, noting that the primary concern is the safety and dependability of the aircraft. Airline operators usually require that 'new' structure be purchased to replace mechanically damaged structure unless the damage is only cosmetic, but many other cases arise where in-service repair is necessary. The techniques, surface preparations, materials, and processes that repair in-service bonded structures are also applicable to manufacturer-based units. The end result of the repair process will be to restore the structural integrity of the bonded article and in some cases to increase the service period over and above the initial design life. Repair considerations, surface preparation, and repair materials are described. Several typical repairs are recounted and illustrated in detail. D.H.

A86-48042**PUMPS FOR 8000 PSI HYDRAULIC SYSTEMS EXAMINED**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, July 1986, p. 32-38.

The 750-1500 hp hydraulic power system requirements that have been projected for next-generation tactical aircraft require 8000-psi hydraulic component technology. Attention is presently given to candidate hydraulic pump designs, with a view to their mechanical type, volumetric output, pump inlet pressure, working fluid temperature, pump operating speed, transient response, and pump control system. The hydraulic systems considered will employ a chlorotrifluoroethylene nonflammable/high viscosity working fluid. O.C.

A86-48130#**FABRICATION OF HIGH-ALUMINA CERAMIC FIXTURES FOR JET ENGINE REPAIR APPLICATIONS**

S. C. KUO and M. WOOD (Cemcom Corp., Lanham, MD) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs (ASME PAPER 86-GT-46)

A new concept of utilizing a castable high-alumina ceramic, instead of machined steel or graphite, to make low-cost non-outgassing jet engine repair fixtures is presented in this paper. The desirable thermophysical and mechanical properties for the fixture material developed are summarized, and a process developed to produce the ceramic fixtures of different configurations and sizes is described. Each of the major production steps is identified in a production flow chart. Specifically, the methods to make the appropriate molds needed for casting the fixture, and the procedures for mixing, casting, curing, drying and sintering the ceramic fixtures are explained in detail. Crack problems and their controls throughout the production process particularly relevant to fixture geometry are discussed in reference to the several prototype fixtures fabricated. Preliminary test results for these fixtures mated with engine stators in a high-temperature furnace are reviewed. Potentials for this fixture material and production processes for other manufacturing applications are also discussed. Author

A86-48271*# Princeton Univ., N. J.**AEROELASTIC BEHAVIOR OF LOW ASPECT RATIO METAL AND COMPOSITE BLADES**

J. F. WHITE, III and O. O. BENDIKSEN (Princeton University, NJ) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 10 p. refs (Contract NAG3-308) (ASME PAPER 86-GT-243)

The aeroelastic stability of titanium and composite blades of low aspect ratio is examined over a range of design parameters, using a Rayleigh-Ritz formulation. The blade modes include a plate-type mode to account for chordwise bending. Chordwise flexibility is found to have a significant effect on the unstalled supersonic flutter of low aspect ratio blades, and also on the stability of tip sections of shrouded fan blades. For blades with a thickness of less than approximately four percent of chord, the chordwise, second bending, and first torsion branches are all unstable at moderately high supersonic Mach numbers. For composite blades, the important structural coupling between bending and torsion cannot be modeled properly unless chordwise bending is accounted for. Typically, aft fiber sweep produces beneficial bending-torsion coupling that is stabilizing, whereas forward fiber sweep has the opposite effect. By using crossed-ply laminate configurations, critical aeroelastic modes can be stabilized. Author

A86-48281#**OPTIMUM DESIGN TECHNIQUE FOR ROTATING WHEELS**

T. HATTORI, H. OHNISHI (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Tsuchiura, Japan), and M. TANEDA (Hitachi, Ltd., Production Engineering Dept., Tokyo, Japan) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 6 p. refs (ASME PAPER 86-GT-255)

Compressor rotors and turbine rotors are subject to centrifugal and thermal loads. These loads increase proportionally with tip speed, pressure ratio, and gas temperature. On the other hand, the rotor weight must be lessened to improve rotor dynamics and restrict bearing load. Thus, an optimum design technique is required, which offers the lightest possible wheel shape under the stress limit restriction. This paper introduces an optimum design system developed for turbo machinery rotors and discusses several application results. The sequential linear programming method is used in the optimizing process, and centrifugal and thermal stress analyses of variable thickness rotating wheels are performed using Donath's method. This system's validity is confirmed by application to uniform strength rotating disk problems and comparison with

analytical results. This optimum design program is then applied to the design of axial flow compressor wheels.

Author

A86-48288#

EVALUATION OF DAMAGE TOLERANCE REQUIREMENTS USING A PROBABILISTIC-BASED LIFE APPROACH

C. G. ANNIS, JR., D. T. HUNTER, and T. WATKINS, JR. (Pratt and Whitney, Engineering Div., West Palm Beach, FL) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 5 p. refs (ASME PAPER 86-GT-266)

This paper presents the results of a study using a probabilistic-based life analysis system to define the impact of damage tolerance requirements now being written into design specifications. An advanced turbine disk design was considered for several combinations of NDE starting with baseline values representative of actual material and NDE capabilities. Significant conclusions are: (1) conventional single-valued descriptions of NDE capability (e.g. 90/95, etc.) are incomplete for comparing competing NDE systems, and (2) the scatter about the mean NDE capability has little influence on system behavior. These conclusions suggest that more complete descriptions of damage tolerance requirements should be considered. NDE requirements, for example, might be better stated in terms of system performance goals - acceptable failure and removal rates - rather than any specific POD/confidence limit requirement.

Author

A86-48311#

QUALITY ASSURANCE IN THE RECONDITIONING OF GAS TURBINE AND COMPRESSOR BLADING COMPONENTS

T. KOROMZAY (Brown, Boveri et Cie, AG, Baden, Switzerland) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 11 p. refs (ASME PAPER 86-GT-299)

Attention is given to the development history, quality standards, manufacturing techniques, and on-site assembly and installation procedures associated with the reconditioning of gas turbine and compressor blades. The reconditioning and repair methods employed encompass superalloy arc welding, brazing, hot isostatic pressing, regenerative heat treatment, deposit stripping, electropolishing, and low pressure plasma spraying.

O.C.

A86-48647

A PARALLEL PROCESSING METHOD FOR SOLVING THE UNSTEADY NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS [UNE METHODE DE CALCUL PARALLELE POUR LA RESOLUTION DES EQUATIONS DE NAVIER-STOKES INSTATIONNAIRES A GRANDS NOMBRES DE REYNOLDS]

L. MANE (ONERA, Direction Moyens Informatiques, Chatillon-sous-Bagneux, France) and T. P. LOC (CNRS, Laboratoire d'Informatique pour la Mecanique et les Sciences de l'Ingenieur, Orsay, France) Academie des Sciences (Paris), Comptes Rendus, Serie II Mecanique, Physique, Chimie, Sciences de l'Univers, Sciences de la Terre (ISSN 0249-6305), vol. 302, no. 18, May 14, 1986, p. 1121-1123, 1125, 1126. In French. DRET-supported research. refs

A finite difference technique is presented for parallel processing simulations of solutions to the full Navier-Stokes equations for flows at high Re. The model requires a compact hermitian discretization of the governing equations, which are decomposed into subdomains. Sample results are provided from applications of the model using the ONERA multiprocessor to simulate the flow around a NACA 0012 airfoil at Re of 40,000 and 100,000 at an angle of attack of 15 deg. The results illustrate the capability of correctly identifying the moment of separation and the laminar-turbulent transition.

M.S.K.

A86-48656

FINITE ELEMENT ANALYSIS AND OPTIMUM DESIGN OF SEMI-MONOCOQUE AIRFRAME STRUCTURES. I - FINITE ELEMENT ANALYSIS

X.-S. LIU (Helicopter Research and Design Institute, People's Republic of China), S. CHIAO, J.-G. CHOU, and J.-S. ZHU (Nanjing Aeronautical Institute, People's Republic of China) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 2. Alexandria, VA, American Helicopter Society, 1985, 14 p. refs

In the present finite element analysis of composite airframe structures, a family of composite flange-and-membrane semimonocoque elements is derived and judged adequate for the determination of primary load paths in most helicopter and aircraft structures of either metallic or composite type. These idealizations are shown to be very efficiently and conveniently implemented on computers, saving substantial amounts of computation time in both analysis and design tasks.

O.C.

A86-48658

TRANSMISSION DESIGN USING FINITE ELEMENT METHOD ANALYSIS TECHNIQUES

C. ALBRECHT (Boeing Vertol Co., Philadelphia, PA) IN: The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Part 2. Alexandria, VA, American Helicopter Society, 1985, 13 p. refs

Attention is given to a FEM design and analysis system for helicopter drivetrain gear stress evaluation, gear resonance determination, and transmission noise reduction. Analyses undertaken by these means can furnish assurance that structural and noise problems do not occur during the qualification test phase of a new transmission system's development. A preprocessor computer program is used to automatically generate a FEM model of complex spur, helical, or spiral bevel gears. A postprocessor is used to present NASTRAN analysis results in a form that is easily interpreted by the program operator.

O.C.

A86-48776

METHOD FOR DETERMINING THE EFFICIENCY OF UTILIZATION OF THE MATERIAL IN A THIN-WALL AIRCRAFT STRUCTURE ACCORDING TO THE STRENGTH CONDITIONS [METODIKA OPREDELENIA EFFEKTIVNOSTI ISPOL'ZOVANIYA MATERIALA V TONKOSTENNOI AVIATIONNOI KONSTRUKTSII PO USLOVIAM PROCHNOSTI]

E. K. LIPIN and I. E. USHAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 2, 1985, p. 58-67. In Russian. refs

The paper formulates the problems of choosing the material and determining its optimal properties for load-bearing elements and thin-wall structures according to a minimum-mass criterion, with fulfillment of requirements of stability, service life, and static and residual strength. Methods for solving these problems are developed which employ solutions of local optimization problems.

B.J.

A86-48830

METHOD FOR THE CALCULATION AND DESIGN OF FUSELAGE FLAPS MADE OF COMPOSITE MATERIALS [METODIKA RASCHETA I PROEKTIROVANIYA STVOROK LIUKOV LETATEL'NYKH APPARATOV IZ KOMPOZITSIONNYKH MATERIALOV]

A. B. KUDRIASHOV and V. F. KUTINOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 5, 1985, p. 74-83. In Russian.

The paper presents method for selecting the thickness and reinforcement of the load-bearing layers of a composite flap of honeycomb structure, and for specifying the characteristics of the end-face, longitudinal, and transverse beams, and of the honeycomb filler. The method used consists of two steps: (1) the application of analytical relationship derived from the minimum-weight conditions and the satisfaction of strength and stiffness requirements and (2) the application of the finite element method.

B.J.

A86-48846**SHAPE OPTIMIZATION OF AIRCRAFT STRUCTURAL ELEMENTS WITH STRESS RAISERS [OPTIMIZATSIYA FORMY ELEMENTOV AVIATSIONNYKH KONSTRUKTSII S KONTSENTRATORAMI NAPRIAZHENII]**

V. I. GRISHIN and F. V. RYBAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 6, 1985, p. 80-89. In Russian. refs

The problem of optimizing the shape of structural elements with minimal stress concentration factors in the presence of structural constraints in the form of inequalities is solved using the steepest descent method. The constraints are included by using penalty functions; the stress field is determined by using the finite element method. V.L.

A86-48988#**FIBRE OPTIC DAMAGE DETECTION IN COMPOSITE STRUCTURES**

B. HOFER (Messerschmitt-Boelkow-Blohm GmbH, Lemwerder, West Germany) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 135-143.

A system of thin light-conducting fibers integrated into a composite structure during its manufacturing process can serve as a reliable automatic remote long-term monitoring device for structural damage. Fractures, cracks, or delaminations in a structure area destroy the optical fibers installed there and thus interrupt the light flow. Various examples of applications in GFRP and especially in CFRP aircraft components are described. The outline of a complete fiber-optic nervous system for large Airbus CFRP components shows how fiber-optic damage detection can contribute to future aircraft maintenance and inspection philosophies. Following the example of other aircraft systems such as engines, computers, etc., the structure, too, can be included in the permanent and automatic central fault-detection system.

Author

A86-49001#**THE DESIGN AND CONSTRUCTION OF A POST BUCKLED CARBON FIBRE WING BOX STRUCTURE**

W. G. BROOKS (Cranfield Institute of Technology, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 238-243. Sponsorship: Ministry of Defence. refs (Contract MOD-2028/0153/XR/STR)

Design and construction techniques are developed for a post buckled carbon fibre reinforced plastic (cfrp) wing box to be used on an aerobatic light aircraft. Following studies of post buckled stiffened panel behavior and the evaluation of various design techniques, a wing box structure has been designed. Construction techniques have then been developed and appraised so that the wing box can be manufactured easily and that the expected high structural efficiency can be realized in practice.

Author

A86-49003#**ANALYTICAL AND EXPERIMENTAL INVESTIGATION ON ADVANCED COMPOSITE WING BOX STRUCTURES IN BENDING INCLUDING EFFECTS OF INITIAL IMPERFECTIONS AND CRUSHING PRESSURE**

E. ANTONA and G. ROMEO (Torino, Politecnico, Turin, Italy) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 255-261. refs

A86-49040#**VARIOUS APPROACHES IN SOLVING STABILITY PROBLEMS FOR SYMMETRIC ANGLE-PLY LAMINATES UNDER COMBINED LOADING**

M. J. JOSIFOVIC and V. LJ. RADOSAVLJEVIC (Beograd, Univerzitet, Belgrade, Yugoslavia) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 573-582. refs

Various elastic stability problems for symmetric angle-ply laminated plates are solved using the energy method and finite difference method. The energy method is applied in considering the buckling problem for rectangular plates that are simply supported along all edges and subjected to both uniform in-plane loads in the X- and Y-direction and constant shear load, simultaneously. Also provided is the solution of buckling problem for simply supported plate under nonuniform compressive load in X-direction, by using the same method. The finite-difference method is applied in solving the buckling problem for rectangular plates under combined loading, with edges that are either simply supported or clamped. Many computer programs in PASCAL language have been developed which enable calculation of the critical buckling loads for different symmetric angle-ply laminates and for different a/b ratios. A comparison between results obtained by two methods for rectangular simply supported plates is presented. The results are in good agreement, but energy method provides values which converge a little more rapidly for the acceptable equivalent computing time.

Author

A86-49068#**MANUFACTURING TECHNOLOGY OF COMPOSITE TORQUE BOX OF VERTICAL FIN**

Z. QUSEN (Beijing Aeronautical Manufacturing Technology Research Institute, People's Republic of China) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 849-859.

Problems encountered in the research and fabrication of all-carbon fiber composite torque boxes with vertical fins are reviewed. The configuration of one of these boxes is described, and data on the dimensions of its skin and spars are given. The selection of the prepreg is addressed, giving its specifications. The processes and technologies used for fabrication and quality control are described. An imitative box test for analyzing stresses and certifying the design of the final product is summarized. Comparisons are made between the calculated value and the actual value of the displacement under loading at several points of the box are given. The assembly of a full-scale box is described and static tests made on it are briefly reported. The advantages of the materials and construction of these boxes, including simplifying structure, saving weight, and improving performance, are summarized.

C.D.

A86-49082#**ON THE OPTIMIZATION OF FLUTTER CHARACTERISTICS OF LAMINATED ANISOTROPIC CYLINDRICAL SHELLS**

G. V. VASILIEV (Institutul National Pentru Creatie Stiintifica si Tehnika, Bucharest, Rumania) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 988-997. refs

The axisymmetrical supersonic flutter of a simply supported circular cylindrical laminated shell with orthotropic or isotropic layers is investigated. A comparative analysis is performed to demonstrate the influence of geometrical and mechanical characteristics of the shell on its critical flutter speed. The purpose of this investigation is to perform the optimization of the flutter characteristics of cylindrical multilayered shells by varying their geometrical, elastical and mechanical parameters. The solution of the problem is obtained using the methodology developed in the papers of Movchan (1956), Krumhaar (1961) and Stepanov (1957), extended to multilayered and orthotropic cylindrical shells. This methodology concerns the application of the linearized Timoshenko shell equations and linear

piston theory, which leads to a nonselfadjoint eigenvalue problem, solved without further approximations. Author

A86-49114#

THE CONTROL AND USE OF RESIDUAL STRESSES IN AIRCRAFT STRUCTURAL PARTS

B. JAENSSON and S.-E. LARSSON (Saab-Scania AB, Linköping, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1337-1346. refs

An account is given of how residual aircraft structural element stresses arise, with a view to their systematic control and to the consequences of their interaction with cyclic deformation phenomena. The residual stresses are noted to be due to deliberate introduction in manufacture, induction by in-service loading, or inadvertent production by heat treatment or mechanical straightening. Attention is given to the ways in which residual stresses can be used to improve the fatigue resistance of structural elements. O.C.

A86-49127#

SOME ASPECTS OF THE RELIABILITY ANALYSIS OF AIRCRAFT STRUCTURES

D. ZHU and F. LIN (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1461-1466. Research supported by the Chinese Aeronautical Establishment. refs

Attention is given to reliability analysis methods yielding the influence of various factors on aircraft structure reliability. Current aircraft fatigue-related design criteria are evaluated; it is noted that the 10 to the -7th/hr (with 95-percent confidence failure probability) recommendation currently in use is inadequate. An estimation method is presented for the parent distribution parameters of laboratory-determined initial lives, together with a modified method employing the F-distribution which is able to straightforwardly estimate flaw detection probability curves. O.C.

A86-49128#

LOAD EXAMINATION OF VEHICLE-BODY OF REINFORCED CYLINDRICAL SHELL IN CASE OF KINEMATIC LOAD

Z. SZABO and P. MICHELBERGER (Budapesti Muszaki Egyetem, Budapest, Hungary) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1467-1474.

A method is presented which is suitable for the estimation of stresses arising in the course of the assembly of reinforced cylindrical shell structures. Attention is given to the case of the bolted joint connecting rings of a helicopter's outrigger tail/fuselage interface. It is assumed that kinematic loading involves neither plastic deformation of the structure nor corrugation of its covers. For the sake of simplification, only a four-frame section of the structure is considered. O.C.

A86-49133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UNIFIED CONSTITUTIVE MATERIALS MODEL DEVELOPMENT AND EVALUATION FOR HIGH-TEMPERATURE STRUCTURAL ANALYSIS APPLICATIONS

R. L. THOMPSON (NASA, Lewis Research Center, Cleveland, OH) and M. T. TONG (Sverdrup Technology, Inc., Cleveland, OH) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1505a-1505s. refs

Unified constitutive material models were developed for structural analyses of aircraft gas turbine engine hot section components with particular application to an isotropic material used for combustor liners. Differential forms of models independently developed were considered in this study. These models combine the interactions of time-dependent (creep) and time-independent (plasticity) inelastic behavior of a material. Predicted stress-strain

responses from these models were evaluated against cyclic isothermal and nonisothermal test results for uniaxial specimens of a nickel-base superalloy. The unified models were implemented in a nonlinear structural analysis code. Two unique NASA Lewis test facilities were used in the evaluation of the models for complex geometry specimens and evaluation of advanced temperature and high-temperature strain measurement instrumentation. Predicted nonlinear structural responses from one of the models for a flat plate and a segment of a conventional combustor liner are presented. Author

A86-49136#

A CONTRIBUTION TO AIRWORTHINESS CERTIFICATION OF GAS TURBINE DISKS

J. DREXLER and J. STATECNY Zprava VZLU, no. Z-47, 1986, p. 1-10. refs

The airworthiness proof of gas turbine disks involves some specific problems connected with the experimental verification of the admissible probability of a hazardous effect due to an individual failure. A simple method for meeting the airworthiness requirements is presented in the case when the disk blade fir-tree attachment number exceeds several tens, the dominating damage mechanism being low cycle fatigue. The structure of the method consists in taking the disk operation or test as an experiment run simultaneously on a group of identical test specimens up to appearance of the cracked attachments cumulative number describing the achievement of the disk limit state. Author

A86-49144

APPLICATION OF STRAIN GAUGE AMPLIFIERS AND COMPUTER TECHNOLOGY TO THE STRENGTH TESTING OF AIRCRAFT [POUZITI TENZOMETRICKYCH ZEŠILOVACU A VYPOČETNI TECHNIKY PRI PEVNOSTNICH MERENICH LETADEL]

R. KOČI Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1986, p. 113-115. In Czech.

A method of strain gauge measurements used on the L-39 aircraft at the manufacturing plant is described. An original design of a measuring circuit with an amplifier for strain gauge measurements is then presented which uses a digital or an analog magnetic recording system. V.L.

A86-49145

CONTACTLESS MEASUREMENT OF THE TORQUE OF AN AIRCRAFT ENGINE [BEZKONTAKTNÍ MERENÍ KROUTICÍHO MOMENTU LETECKÉHO MOTORU]

E. KUCERA Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1986, p. 117-119. In Czech. refs

A86-49148

PRACTICAL APPLICATIONS OF TESLA SEMICONDUCTOR PRESSURE SENSORS [PRAKTICKÉ APLIKACE POLOVODICOVÝCH TLAKOVÝCH ČIDEL TESLA]

A. MENSÍK Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1986, p. 161-165. In Czech.

The paper describes some applications of Semiconductor Pressure Sensors, Types TM 530, TM 610, and TM 630, within a temperature range from -55 to +80 C and +125 C. Given are the measured parameters of pressure sensors, the methods of their attachment in the transducer, the compensation of temperature effects on characteristics of sensors, and the attained results. Author

A86-49572#

RESIDUAL STRENGTH PREDICTION FOR PLANKED WING TENSION SURFACES

R. B. SAYER (Lockheed-Georgia Co., Marietta) AIAA, Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, 19 p. (AIAA PAPER 86-0941)

A method for the accurate prediction of static residual strength for metallic multipanel wing box tension surfaces subsequent to failure of one or more panels due to fatigue cracks is presented.

A nonlinear analysis is applied to finite element models incorporating a representation of the spanwise splice critical area in the remaining intact panels, where the spanwise splice fasteners create a stress concentration through transfer of load from the failed panels. The model stress/strain state at a failure has been correlated for a series of component-type specimens statistically tested to failure between 1983 and 1984. Use of the material failure criterion eliminates the need for making assumptions concerning the critical stress/strain state, and results demonstrate that predictions made using such assumptions can be either quite conservative or unconservative, depending on the panel structure geometry and the strength/stiffness of the spanwise splice fasteners.

R.R.

A86-49918

THE EFFECT OF A FAULT ON THE STIFFNESS AND THE NATURAL FREQUENCY OF A PLATE IN BENDING [VLIANIE DEFEKTA NA ZHESTKOST' I CHASTOTU SOBSTVENNYKH KOLEBANII PLASTINY PRI IZGIBE]

I. M. NASONKIN and O. T. SIDOROV Defektoskopiia (ISSN 0130-3082), no. 6, 1986, p. 80-83. In Russian. refs

The effect of a slot (crack) in a rectangular plate on the flexural stiffness of the plate and its natural frequency is analyzed using the energy method. The results obtained are found to be in good agreement with experimental data for an aileron panel with two slots. It is concluded that defects in complex aircraft structures, such as wings or ailerons, can be detected by accurately measuring their natural frequencies.

V.L.

A86-50254#

APPLICATIONS OF THERMAL IMAGER DEVICES INCL. MODELLING ASPECTS

H.-D. V. BOEHM (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IEE, Conference on Photoelectronic Imaging, London, England, Sept. 10, 11, 1985, Paper. 8 p. refs (MBB-UD-462-85-OE)

Thermal imager (TI) modeling aspects are discussed along with the detection, recognition and identification ranges. Ground/laboratory tests have been performed on nine TIs with different detector technologies, in addition to helicopter flight tests of three TIs. As part of EUROVISIONIK, a nose-mounted pilot visionics system with a high resolution TI will be installed on the PAH 2 and HAC 3G helicopters.

R.R.

A86-50258*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

IMPLICIT HYBRID SCHEMES FOR THE FLUX-DIFFERENCE SPLIT, THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS

P.-M. HARTWICH, C.-H. HSU, and C.-H. LIU (NASA, Langley Research Center, Hampton, VA) Chinese Aerodynamics Research Society, International Conference on Numerical Methods in Fluid Dynamics, 10th, Beijing, People's Republic of China, June 23-27, 1986, Paper. 6 p. refs

Implicit hybrid algorithms employing symmetric planar Gauss-Seidel (SPGS) relaxation and either block-tridiagonally structured coefficient matrices (AF-SPGS) or block-triangular coefficient matrices (LU-SPGS) are derived to solve the flux-difference-split Navier-Stokes equations for three-dimensional incompressible flow in an upwind scheme. The physical basis of the approach is discussed, and results for problems involving vortex flow around a thin delta wing at Reynolds numbers 900,000 and 10,000 are presented graphically. It is found that AF-SPGS converges faster on vector computers which depend on long vector lengths to achieve optimum performance, whereas LU-SPGS is preferable on sequentially operating machines and vector computers using shorter vector lengths.

T.K.

A86-50260*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

A WIDE BANDWIDTH ELECTROSTATIC FIELD SENSOR FOR LIGHTNING RESEARCH

K. P. ZAEFFEL (NASA, Langley Research Center, Hampton, VA) International Conference on Lightning and Static Electricity, Dayton, OH, June 24-26, 1986, Paper. 11 p. refs

Data obtained from UHF Radar observation of direct-lightning strikes to the NASA F-106B airplane have indicated that most of the 690 strikes acquired during direct-strike lightning tests were triggered by the aircraft. As an aid in understanding the triggered lightning process, a wide bandwidth electric field measuring system was designed for the F-106B by implementing a clamped-detection signal processing concept originated at the Air Force Cambridge Research Lab in 1953. The detection scheme combines the signals from complementary stator pairs clamped to zero volts at the exact moment when each stator pair is maximally shielded by the rotor, a process that restores the dc level lost by the charge amplifier. The new system was implemented with four shutter-type field mills located at strategic points on the airplane. The bandwidth of the new system was determined in the laboratory to be from dc to over 100 Hz, whereas past designs had upper limits of 10 Hz to 100 Hz. To obtain the undisturbed electric field vector and total aircraft charge, the airborne field mill system is calibrated by using techniques involving results from ground and flight calibrations of the F-106B, laboratory tests of a metallized model, and a finite-difference time-domain electromagnetic computer code.

Author

N86-31827*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

HIGH SPEED VISCOUS FLOW CALCULATIONS ABOUT COMPLEX CONFIGURATIONS

D. S. CHAUSSEE Apr. 1986 21 p (NASA-TM-88237; A-86199; NAS 1.15:88237) Avail: NTIS HC A02/MF A01 CSCL 20D

Applications of the NASA Ames Parabolized Navier-Stokes (PNS) code to a variety of complex generic configurations is presented. The algorithm, boundary conditions, initial conditions, and grid generators are discussed as applied to these configurations. The PNS code was used as the mainline procedure to numerically simulate the viscous supersonic flow over these generic configurations. The turbulence model that was used in this study is the Baldwin-Lomax model. The boundary conditions are the usual viscous no slip at the wall, and a characteristic procedure is used to fit the bow shock wave which is the outermost boundary. An elliptic grid generator is employed to discretize the flow domain. In addition, an equilibrium air capability has been incorporated into the code. It uses the curve fits of Tannehill, et al. The flow regimes vary from a Mach number of 2 up to 25. Both laminar and turbulent flow are considered. Varying angles of attack have also been computed. Configurations vary from simple cone-type bodies to lifting winged bodies, such as the space shuttle or the generic supersonic cruise fighter.

Author

N86-31860# Department of the Air Force, Washington, D.C.

MULTIPLE THERMOCOUPLE TESTING DEVICE Patent

J. R. HILDEBRAND and K. J. SOBANSKI, inventors (to Air Force) 18 Feb. 1986 11 p Supersedes AD-D009951 (AD-D012276; US-PATENT-4,571,689; US-PATENT-APPL-SN-435515; US-PATENT-CLASS-364-481) Avail: NTIS Avail: US Patent and Trademark Office CSCL 09E

An automated multiple thermocouple testing device determines short and open circuits in a thermocouple system. The thermocouple system that has a plurality of temperature probes, each probe has a first thermocouple. The device applies a direct current voltage to the first thermocouple to cause heating in the second thermocouple and a second thermocouple and then reads the temperature response of the second thermocouple. The first thermocouples have a common lead and the second thermocouples are connected in two parallel groups. The temperature output of the second thermocouple is digitized and read by a computer. These readings are compared to criteria which determine if there

is an open circuit. Before the open circuit test is applied, the device also determines which thermocouple probe has a possible short circuit. This device can automatically test for short and open circuits in a thermocouple system within a few minutes without the necessity of removing the probes from their installed position. This device was adapted to perform the above testing on a F100 fan turbine inlet temperature (FTIT) system. GRA

N86-31872# Institut Franco-Allemand de Recherches, St. Louis (France).

INTERFEROMETRIC HOLOGRAPHIC CINEMATOGRAPHY [CINEHOTOGRAPHIE INTERFEROMETRIQUE]

H. FAGOT 12 Jul. 1985 17 p In FRENCH Presented at HOLOPRO 85 Conference, Belfort, France, 21 Jun. 1985 (ISL-CO-219/85; ETN-86-97628) Avail: NTIS HC A02/MF A01

Double exposition holographic interferometry was employed to obtain a 35 mm scientific film. The deformations and displacements of a loudspeaker were visualized at 20 to 70 Hz vibration frequencies. A 30 mJ YAG laser was used. The two successive pulses of each hologram are produced at 4 ms interval by the same laser beam. The 35 mm camera operates at 10 Hz. The device is limited to low frequency phenomena. The development of higher frequency systems is discussed with a view to nondestructive control of vibration in aircraft structures. ESA

N86-31917 Westland Helicopters Ltd., Yeovil (England). Dynamics Dept.

DYNAMIC ANALYSIS: CORRELATION OF THEORY WITH EXPERIMENT Final Report

A. MCLAUGHLIN Jun. 1983 94 p (Contract MODA26B/10) (RP661; DYN/83/10; BR97157; ETN-86-97258) Avail: Issuing Activity

The NASTRAN finite element system with superelements was used to compute the normal modes of vibration and transfer functions of a helicopter. Using measured model damping factors, transfer functions in the cockpit and cabin areas for main rotor head shear and moment input were synthesized. Fair agreement in mode shape is obtained for the two NASTRAN analyses, but the correlation between the shake test modes and those from the WHL NASTRAN analysis is disappointing. The transfer function correlation is also poor, though better agreement with direct measurement is obtained for the transfer function synthesis from the WHL NASTRAN modes than for the corresponding synthesis from the measured mode shapes. The measured transfer functions could not be synthesized from the measured mode shapes. The aims of the study were not realized in full due to the poor quality of the results from the shake tests. ESA

N86-32746# Department of the Air Force, Washington, D.C. **LOW MASS DIFFUSION BONDING TOOLS Patent Application** W. R. MACKENZIE, inventor (to Air Force) 24 Feb. 1986 27 p (AD-D012295; US-PATENT-APPL-SN-832114) Avail: NTIS HC A03/MF A01 CSCL 131

This invention relates to the field of tooling spacer blocks or mandrels enabling fabrication of complex structures from individual component elements using diffusion bonding and similar element integrating techniques. This patent application describes diffusion bonding spacer block tooling or mandrels having low physical mass and low thermal mass and specially adapted to the fabrication of airframe component elements such as titanium structures. Alternate uses for the disclosed structure and a plurality of spacer block example configurations and preferred stainless steel mandrel material are included, along with a sequence for using the disclosed spacer blocks. GRA

N86-32779# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

REVIEW OF AERONAUTICAL FATIGUE INVESTIGATIONS IN THE NETHERLANDS DURING THE PERIOD MARCH 1983 - FEBRUARY 1985

J. B. DEJONGE Mar. 1985 32 p Presented at 19th ICAF Conference, Pisa, Italy, 20-21 May 1985 (NLR-MP-85025-U; B8664738; ETN-86-97672) Avail: NTIS HC A03/MF A01

Over 40 abstracts and references from studies of flight simulation, loads, crack propagation, joint fatigue, metallic materials, manufacturing effects, corrosion fatigue, composite fatigue, and nondestructive inspection connected to aeronautical fatigue are presented. ESA

N86-32781# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

SHORT CRACKS IN AEROSPACE STRUCTURES

R. J. H. WANHILL Jul. 1985 18 p Presented at Symposium on the Behavior of Short Fatigue Cracks, Sheffield, England, 26-28 Sep. 1985

(NLR-MP-85054-U; B8665499; ETN-86-98032) Avail: NTIS HC A02/MF A01

The engineering significance of short fatigue cracks in aerospace structures is examined with respect to the design and operating requirements of safety and durability. It is shown that this significance is limited to the safety of engine parts, notably disks and blades, and the durability of metallic airframe structures. ESA

N86-32784# Societe Nationale Industrielle Aerospatiale, Toulouse (France).

COMPUTATION OF THE STRESS INTENSITY FACTOR IN STIFFENED PANELS (BUILT IN OR ADHESIVE BONDED STIFFENERS) Final Report [CALCUL DU FACTEUR D'INTENSITE DE CONTRAINTE DANS LES PANNEAUX RAIDIS: RAIDISSEURS INTEGRES OU COLLES]

B. LACHAUD 2 Sep. 1985 47 p In FRENCH (Contract DRET-83-34-355)

(SNIAS-436.021/85; ETN-86-97877) Avail: NTIS HC A03/MF A01

A theoretical study of crack propagation in stiffened panels is presented. The application of the superposition principle and analytical techniques allow the development of a method called displacement compatibility analysis. The procedure may be applied to fundamental parametric studies in aircraft design. A computer program was prepared to compare the results obtained with this method with other methods. The procedure is shown to be efficient in accuracy and computer time cost. ESA

N86-32785# Ecole Nationale Supérieure des Arts et Metiers, Bordeaux (France). Lab. Arts et Metiers d'Etude de la Fatigue.

FATIGUE RESISTANCE OF HIGH QUALITY STEELS UNDER MULTIAXIAL LOAD Thesis [RESISTANCE A LA FATIGUE DES ACIERS A HAUTES CARACTERISTIQUES EN CHARGEMENT MULTIAXIAL]

C. FROUSTEY Oct. 1985 54 p In FRENCH (Contract DRET-84-1214)

(ETN-86-97878) Avail: NTIS HC A04/MF A01

The measurement procedures and the computation techniques for simultaneous torsion and flexion loads were studied to improve design procedures of helicopter rotating parts. The study includes the performance tests of a hydraulic multiaxial fatigue test machine and a bibliographic analysis of multiaxial fatigue design criteria. It is shown that the test machine is operational and that the three design criteria methods studied give slightly different results in combined flexion and torsion, and that the Dang Van critical point position differs from the results derived from Sines or Grossland. ESA

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A86-47401**GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, WILLIAMSBURG, VA, AUGUST 18-20, 1986, TECHNICAL PAPERS**

Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 983 p. For individual items see A86-47402 to A86-47509.

Recent developments in navigation, guidance, and control technology are discussed in reviews and reports, with an emphasis on aeronautical and space applications. Topics examined include flight-management systems for commercial jets, nonlinear adaptive control of an elastic robotic arm, the Space Telescope precision-pointing control system, spin-axis controllers for GEO satellites, dynamics and control of slew maneuvers of a large flexible spacecraft, and multicriterion approaches to optimization of linear regulators. Consideration is given to the effect of time delay on flying qualities, laser feedback controls for passive ring-laser gyros, eigensystem synthesis for active flutter suppression on an oblique-wing aircraft, terminal control factors for the carrier landing task, and a linear-quadratic guidance law for solid-fuel space-based interceptors. T.K.

A86-47417*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TIME SCALE ANALYSIS OF A CLOSED-LOOP DISCRETE OPTIMAL CONTROL SYSTEM

D. S. NAIDU and D. B. PRICE (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 138-143. refs

(AIAA PAPER 86-1995)

A two-time scale discrete control system is considered. The closed-loop optimal linear quadratic (LQ) regulator for the system requires the solution of a full-order algebraic matrix Riccati equation. Alternatively, the original system is decomposed into reduced-order slow and fast subsystems. The closed-loop optimal control of the subsystems requires the solution of two algebraic matrix Riccati equations of order lower than that required for the full-order system. A composite, closed-loop suboptimal control is created from the sum of the slow and fast feedback optimal controls. Numerical results obtained for an aircraft model show a very close agreement between the exact (optimal) solutions and computationally simpler composite (suboptimal) solutions. The main advantage of the method is the considerable reduction in the overall computational requirements for the closed-loop optimal control of digital flight systems. Author

A86-47418#**SINGLE-STATE OBSERVER DESIGN CONSIDERATIONS FOR AIRCRAFT APPLICATION**

W. J. GAUGH (Northrop Corp., Advanced Systems Div., Pico Rivera, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 144-154. refs

(AIAA PAPER 86-1996)

A single-state Luenberger (1971) deterministic observer is developed analytically to reconstruct aircraft augmentation signals for flight-control software in cases where sensor measurements are missing. The observer equations and equation constraints are derived; a singular-value decomposition is performed; a Gopinath

(1971) matrix solution and an analytic solution are obtained; and the robustness of the system is investigated by means of Monte Carlo simulations. The sideslip-offset response for a typical aircraft without and with the observer is shown in graphs, and the standard deviations for various mode components are given in a table. The implications of the single-state findings for the design of multistate observers are considered. T.K.

A86-47439#**RT-BUILD - AUTOMATIC GENERATION OF ADA CODE FOR FLIGHT CONTROL APPLICATIONS**

L. L. LEHMAN, S. P. HOUTCHENS, M. NAVAB, and S. C. SHAH (Integrated Systems, Inc., Palo Alto, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 352-356.

(AIAA PAPER 86-2088)

Key issues in developing real-time control software for flight control applications are discussed, and the relationship of RT-BUILD to these issues is examined. RT-BUILD is an expert control system programmer that creates systems. The capabilities of RT-BUILD are reviewed, and the two major components of its implementation, the Ada source code generator and the debug executive, and the crucial architectural details of stand-alone control applications that are generated by RT-BUILD are discussed. RT-BUILD application is examined by viewing it in terms of four distinct parts: a system initializer, a periodic application-level scheduler, synchronous I/O drivers, and subsystem update computations. C.D.

A86-47466*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PERFORMANCE CHARACTERISTICS OF AN ADAPTIVE CONTROLLER BASED ON LEAST-MEAN-SQUARE FILTERS

R. S. MEHTA and S. J. MERHAV (NASA, Ames Research Center, Moffett Field, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 581-590. refs

(AIAA PAPER 86-2160)

A closed-loop, adaptive-control scheme that uses a least-mean-square filter as the controller model is presented, along with simulation results that demonstrate the excellent robustness of this scheme. It is shown that the scheme adapts very well to unknown plants, even those that are marginally stable, responds appropriately to changes in plant parameters, and is not unduly affected by additive noise. A heuristic argument for the conditions necessary for convergence is presented. Potential applications and extensions of the scheme are also discussed. Author

A86-47476#**AUTOMATED POLE PLACEMENT ALGORITHM FOR MULTIVARIABLE OPTIMAL CONTROL SYNTHESIS**

D. J. COLLINS (U.S. Naval Postgraduate School, Monterey, CA) and W. K. CHOW IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 663-670. Navy-sponsored research. refs

(AIAA PAPER 86-2196)

This work addresses the application of numerical optimization technique to the pole-placement problem in multivariable optimal control. An algorithm is developed to select a set of weighting matrix element such that the conventional transient response criteria are satisfied. The designer has the choice of specifying the state weighting matrix and/or the control weighting matrix as the design parameter to be varied. The method was applied to the design of two multivariable systems in which the open-loop poles were moved one at a time to a desired location. Results indicated that this method produces robust feedback controllers. This formulation also provides good insight to the problem for the designer and is therefore a useful tool in multi-variable control synthesis. Author

A86-47477#

A PRELIMINARY INVESTIGATION OF H (INFINITY) OPTIMIZATION

T. E. MCQUADE and S. S. BANDA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 671-680. refs
(AIAA PAPER 86-2197)

In this paper the topic of H (infinity) controller synthesis is considered. The paper develops the mathematical tools to translate the given design task into a General Distance Problem. Using the techniques of best approximation, the controller is determined. The paper contains an application of the method to a simple aircraft flight control problem. Author

A86-47479#

A CONTROLLER FOR ROBUST ASYMPTOTIC TRACKING IN SYSTEMS WITH TIME-VARYING UNCERTAINTIES

T. H. HOPP and W. E. SCHMITENDORF (Northwestern University, Evanston, IL) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 691-694. refs

(Contract NSF ECS-84-15591; AF-AFOSR-ISSA-85-00051)
(AIAA PAPER 86-2199)

A class of linear systems is considered, in which there is time-varying uncertainty and additive disturbances. A control law is determined which produces practical tracking. Practical tracking guarantees that the asymptotic tracking error can be made arbitrarily small. Existing theory provides asymptotic tracking only for systems where the uncertainty is unknown but constant. The theory presented here is able to accommodate the more realistic situation of time-varying uncertainty. Author

A86-47484#

COOPERATIVE SYNTHESIS OF CONTROL AND DISPLAY AUGMENTATION

D. K. SCHMIDT (Purdue University, West Lafayette, IN) and S. GARG IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 732-742. refs
(AIAA PAPER 86-2204)

The Cooperative Control Synthesis (CCS), previously developed to synthesize control augmentation so as to optimize pilot opinion rating, is extended to the synthesis of display augmentation for closed-loop manual control tasks. The procedure allows simultaneous solution for the display augmentation and control augmentation gains using optimal-control techniques, and explicitly includes task related and pilot-centered requirements in the design objectives. Use of the methodology is demonstrated by considering a compensatory tracking task and k/s-squared controlled element dynamics. Analytical evaluation of the various control and display augmentation designs synthesized using the cooperative methodology indicates that simultaneous synthesis may lead to a better control display trade-off, as opposed to designing the display after the control augmentation has already been designed. Author

A86-47505#

MATRIX PLUS WITH HYPER-BUILD - ACCELERATING CONTROL DESIGN, ANALYSIS, AND SIMULATION

M. A. FLOYD, R. WILSON, and R. PINE (Integrated Systems, Inc., Palo Alto, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 928-937. refs
(AIAA PAPER 86-2085)

The Control Design, Analysis, and Simulation package MATRIXx has represented the state-of-the-art in Computer-Aided Control Engineering (CACE) packages since its introduction in 1982, with its numerous enhancements and substantive modifications. The

latest software system, MATRIXx Plus, incorporates the major module, HYPER-BUILD, a simulation generator, along with other substantial improvements. Author

A86-48577*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

AN ARTIFICIAL INTELLIGENCE APPROACH TO ONBOARD FAULT MONITORING AND DIAGNOSIS FOR AIRCRAFT APPLICATIONS

P. C. SCHUTTE and K. H. ABBOTT (NASA, Langley Research Center, Hampton, VA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 9 p. refs
(AIAA PAPER 86-2093)

Real-time onboard fault monitoring and diagnosis for aircraft applications, whether performed by the human pilot or by automation, presents many difficult problems. Quick response to failures may be critical, the pilot often must compensate for the failure while diagnosing it, his information about the state of the aircraft is often incomplete, and the behavior of the aircraft changes as the effect of the failure propagates through the system. A research effort was initiated to identify guidelines for automation of onboard fault monitoring and diagnosis and associated crew interfaces. The effort began by determining the flight crew's information requirements for fault monitoring and diagnosis and the various reasoning strategies they use. Based on this information, a conceptual architecture was developed for the fault monitoring and diagnosis process. This architecture represents an approach and a framework which, once incorporated with the necessary detail and knowledge, can be a fully operational fault monitoring and diagnosis system, as well as providing the basis for comparison of this approach to other fault monitoring and diagnosis concepts. The architecture encompasses all aspects of the aircraft's operation, including navigation, guidance and controls, and subsystem status. The portion of the architecture that encompasses subsystem monitoring and diagnosis was implemented for an aircraft turbofan engine to explore and demonstrate the AI concepts involved. This paper describes the architecture and the implementation for the engine subsystem. Author

A86-48595

AREA EQUIVALENT METHOD (AEM) ON VISICALC AND LOTUS 1-2-3 - THE FEDERAL AVIATION ADMINISTRATION'S SPREADSHEET PROGRAMS FOR PREDICTING NOISE EXPOSURE CONTOUR AREAS AROUND AN AIRPORT

T. L. CONNOR and D. G. WARREN (FAA, Office of Environment and Energy, Washington, DC) IN: NOISE-CON 85 - Computers for noise control; Proceedings of the National Conference on Noise Control Engineering, Columbus, OH, June 3-5, 1985. New York, Noise Control Foundation, 1985, p. 393-400.

A86-48760

METHODS FOR MINIMIZING BOOLEAN FUNCTIONS IN THE AUTOMATION OF EXPERIMENTAL STUDIES OF THE SURVIVABILITY OF AIRCRAFT STRUCTURES [METODY MINIMIZATSII BULEVYKH FUNKTSII V AVTOMATIZATSII EKSPERIMENTAL'NYKH ISSLEDOVANIИ ZHIVUCHESTI AVIAKONSTRUKTSII]

V. Z. STRYGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 16, no. 1, 1985, p. 81-92. In Russian. refs

A method for minimizing Boolean functions is proposed which employs polynomial-limited algorithms. A method is also proposed for the synthesis of a class of code converters using generalized logic formulas. These methods are used to obtain minimum structures of code converters for measuring the length of fatigue cracks by means of N-filament transducers of consecutive rupture ($N = 16$ and 250). The converters contain a factor of 17 and 300 , respectively, fewer components than nonminimized converters. The minimized converters have been used in an automated fault detection system for analyzing the survivability (fracture toughness) of large structural components of aircraft. V.L.

A86-48987#

AUTOMATED STRUCTURAL OPTIMISATION AT WARTON

R. I. KERR and D. THOMPSON (British Aerospace, PLC, Military Aircraft Div., Preston, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 130-134.

The development and application of ECLIPSE, a weight-minimizing aircraft-structure-optimization program based on the constant-energy-density concept, are described. ECLIPSE has been improved by adding stiffness-based criteria to permit treatment of generalized displacement, efficiency, roll rate, divergence speed, natural frequency, frequency separation, and flutter speed; and provisions have been made to handle problems of local panel buckling, local panel pressures, brazier loads, minimum or fixed size requirements, multiple sets of fixations, and limitations imposed by the geometry of fiber-reinforced composites. Applications to preliminary sizing, weight estimation, parametric studies, topological optimization, and check stressing are presented graphically and briefly characterized. T.K.

A86-48992#

NEAR-OPTIMAL FEEDBACK CONTROL FOR THREE-DIMENSIONAL INTERCEPTIONS

J. SHINAR (Technion - Israel Institute of Technology, Haifa), K. H. WELL (DFVLR, Oberpfaffenhofen, West Germany), and B. JARMARK (Saab-Scania, AB, Linköping, Sweden) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 161-171. refs

Two feedback-approximation methods for the optimal control of an interceptor aircraft in a medium-range scenario are presented. One method is an advanced application of forced singular perturbation techniques, while the other is an updated version of a first-order differential dynamic-programming algorithm. The feedback approximations are compared to the exact open-loop optimal-control solution obtained by a multiple-shooting algorithm. The comparison shows that the accuracy of both feedback approximations is very satisfactory. The results emphasize the attractiveness of the feedback algorithms for airborne implementation. Author

A86-49094*# Purdue Univ., West Lafayette, Ind.

INTEGRATED STRUCTURE/CONTROL DESIGN - PRESENT METHODOLOGY AND FUTURE OPPORTUNITIES

T. A. WEISSHAAR (Purdue University, West Lafayette, IN), J. R. NEWSOM (NASA, Langley Research Center, Hampton, VA), T. A. ZEILER, and M. G. GILBERT (PRC Kentron, Inc., Hampton, VA) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1119-1128. refs

Attention is given to current methodology applied to the integration of the optimal design process for structures and controls. Multilevel linear decomposition techniques proved to be most effective in organizing the computational efforts necessary for ISCD (integrated structures and control design) tasks. With the development of large orbiting space structures and actively controlled, high performance aircraft, there will be more situations in which this concept can be applied. K.K.

A86-49507#

FAILURE DETECTION IN A FLIGHT CONTROL SYSTEM BY THE MODIFIED SEQUENTIAL PROBABILITY RATIO TEST

T. HASHIMOTO and H. KIMURA (Kumamoto Institute of Technology, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 46, March 1986, p. 95-103.

The possibility to detect failures occurring in the control systems represents an important factor for the enhancement of the safety and reliability of aerospace vehicles. Hashimoto and Kimura (1985) have discussed the design of such failure detection systems, taking into account an approach based on the modified sequential probability ratio test. The considered design method is now applied to the design of a detector which should detect parameter failures

occurring in the lateral stability augmentation system of a Space Shuttle Orbiter. A bank of Kalman filters is utilized in the design of the failure detector. Attention is given to details regarding the design method, the detection of failure in an aircraft stability augmentation system, and a digital simulation study. G.R.

A86-49627*

National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A KNOWLEDGE-BASED EXPERT SYSTEM FOR SCHEDULING OF AIRBORNE ASTRONOMICAL OBSERVATIONS

P. R. NACHTSHEIM, W. B. GEVARTER (NASA, Ames Research Center, Moffett Field, CA), J. C. STUTZ, and C. P. BANDA (Informatics General Corp., Palo Alto, CA) IN: Coupling symbolic and numerical computing in expert systems; Proceedings of the Workshop, Bellevue, WA, August 27-29, 1985. Amsterdam, North-Holland, 1986, p. 217-229. refs

KAOS (Kuiper Airborne Observatory Scheduler) is a knowledge-based expert system developed at NASA Ames Research Center to assist in route planning of a C-141 flying astronomical observatory. This program determines a sequence of flight legs that enables sequential observations of a set of heavenly bodies derived from a list of desirable objects. The possible flight legs are constrained by problems of observability, avoiding flyovers of warning and restricted military zones, and running out of fuel. A significant contribution of the KAOS program is that it couples computational capability with a reasoning system. Author

N86-33042# National Aeronautical Lab., Bangalore (India). Systems Engineering Div.

SIX DEGREE OF FREEDOM SIMULATION SOFTWARE

K. S. GOVINDARAJ, J. K. SRIDHAR, P. MADHURANATH, and B. S. BHAGAWAN Jul. 1986 37 p (NAL-PD-SE-8614) Avail: NTIS HC A03/MF A01

The methodology for realizing a general six degree of freedom aircraft simulation on UNIVAC was documented by taking CESSNA 172 as an example. The software package was designed, developed, and validated by making the program trim the aircraft for a flight condition and then exciting the longitudinal and lateral modes. The results compare well with those reported in literature. The software structure is designed to simulate any known aircraft and enables modular addition of complex flight control systems, turbulence and landing gear dynamics. Author

N86-33053# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

SIMULATION AND OPTIMIZATION TECHNIQUES IN COMPUTER AIDED DESIGN

R. F. VANDENDAM 22 Feb. 1985 50 p In DUTCH; ENGLISH summary (NLR-MP-85022-U; B8665120; ETN-86-97670) Avail: NTIS HC A03/MF A01

The place and the potential of numerical simulation and optimization techniques in engineering design processes, as well as their use by the designer are discussed. The principles underlying these techniques are outlined and the various methods are reviewed. Examples of applications are presented in order to illustrate their usefulness in design processes. Attention was paid to the integration of these techniques into structured systems for computer aided design, and to the implementation of these systems in the organization infrastructure. ESA

N86-33054# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

AN INFRASTRUCTURE FOR INFORMATION PROCESSING FOR COMPUTER AIDED DESIGN

W. LOEVE May 1985 24 p In DUTCH; ENGLISH summary Presented at Colloquium Toepassingsgerichte Informatica, Leiden, Netherlands, 24 Apr. 1985 (NLR-MP-85038-U; B8664046; ETN-86-97677) Avail: NTIS HC A02/MF A01

An infrastructure for computer aided design in industry is described. A central engineering data base management system

was introduced for information safeguarding and as a means for information exchange between different processes applied to information. Technical and organizational aspects are discussed. The infrastructure has to be developed stepwise. For economic reasons software must be reusable during the development process of the infrastructure. ESA

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A86-47971#**ACOUSTIC EFFECT ON STALL HYSTERESIS FOR LOW REYNOLDS NUMBER LAMINAR FLOW**

C. G. SCHAEFER, JR. AIAA Student Journal (ISSN 0001-1460), vol. 24, Summer 1986, p. 4-9. refs

An experimental investigation was conducted in the Virginia Tech Stability Wind Tunnel to determine the effect of sound waves on the separated laminar boundary layer of a wing at low Reynolds numbers. Also studied was the effect of Reynolds number on the stall hysteresis behavior of the airfoil at Reynolds numbers between 100,000 and 300,000. It was found that increasing the Reynolds number changed the location and magnitude of the maximum lift coefficient. The stall hysteresis loop, a phenomenon that occurs only at low Re, in which the α at flow separation and that at reattachment are not identical, was also found to change with increasing Reynolds numbers. It was found that sound could be used to excite turbulence in a separated laminar boundary layer and cause flow reattachment via a laminar bubble. The required sound frequency and level were found to vary with Reynolds number and angle of attack. Author

A86-48590* Auburn Univ., Ala.**THE EFFECT ON THE TRANSMISSION LOSS OF A DOUBLE WALL PANEL OF USING HELIUM GAS IN THE GAP**

M. S. ATWAL (Paul S. Veneklasen and Associates, Santa Monica, CA) and M. J. CROCKER (Auburn University, AL) IN: NOISE-CON 85 - Computers for noise control; Proceedings of the National Conference on Noise Control Engineering, Columbus, OH, June 3-5, 1985. New York, Noise Control Foundation, 1985, p. 187-192. NASA-supported research. refs

The possibility of increasing the sound-power transmission loss of a double panel by using helium gas in the gap is investigated. The transmission loss of a panel is defined as ten times the common logarithm of the ratio of the sound power incident on the panel to the sound power transmitted to the space on the other side of the panel. The work is associated with extensive research being done to develop new techniques for predicting the interior noise levels on board high-speed advanced turboprop aircraft and reducing the noise levels with a minimum weight penalty. Helium gas was chosen for its inert properties and its low impedance compared with air. With helium in the gap, the impedance mismatch experienced by the sound wave will be greater than that with air in the gap. It is seen that helium gas in the gap increases the transmission loss of the double panel over a wide range of frequencies. D.H.

A86-48596* Cornell Univ., Ithaca, N.Y.**BROADBAND NOISE OF PROPELLERS AND ROTORS**

A. R. GEORGE and S.-T. CHOU (Cornell University, Ithaca, NY) IN: NOISE-CON 85 - Computers for noise control; Proceedings of the National Conference on Noise Control Engineering, Columbus, OH, June 3-5, 1985. New York, Noise Control Foundation, 1985, p. 461-468. NASA-supported research. refs

Three categories of rotor noise (discrete frequency noise, impulsive noise, and broadband noise) are described and a study

made of broadband noise is reported. Broadband noise has a continuous spectrum and is caused by disturbances which are not precisely repeated at each blade revolution but are basically due to some sort of turbulence-blade interactions. Source mechanisms include: inflow turbulence noise, boundary layer trailing edge noise, tip vortex noise, and several uncommon mechanisms. Broadband noise analyses are reviewed and calculations based on various analyses are compared to each other and to some available experimental data. Several satisfactory analyses are discussed and their limitations are delineated. Twenty-two references are cited. D.H.

A86-48597**MODELLING OF ACOUSTIC RADIATION PROBLEMS ASSOCIATED WITH TURBOMACHINERY AND ROTATING BLADES**

W. EVERSMAN (Missouri-Rolla, University, Rolla) IN: NOISE-CON 85 - Computers for noise control; Proceedings of the National Conference on Noise Control Engineering, Columbus, OH, June 3-5, 1985. New York, Noise Control Foundation, 1985, p. 469-476. refs

Results are reviewed of an extensive study directed toward the creation of practical computational schemes for the prediction of turbofan and propeller acoustic radiation. The principal challenges were found to be wavelengths relatively short compared to significant geometrical scales, the requirement to model acoustic propagation in a nonuniform steady inlet flow, and the necessity to model an infinite domain. These difficulties were solved by establishing a suitable weak formulation of the problem upon which a Galerkin finite element scheme was developed. It was determined that a similar weak formulation could be used to model rotating blade noise sources within ducts and in the free field. The key element was the observation that with a suitable structuring of the weak problem, acoustic dipoles representing the rotating blade lift distribution could be accurately modelled and that blade lift distribution could be used as the acoustic input (Eversman and Steck, 1984). Brief descriptions are given of the formulations of the turbofan and propeller problems as well as example calculations. D.H.

A86-48740**USE OF ACOUSTIC INTENSITY MEASUREMENTS IN THE CHARACTERIZATION OF JET NOISE SOURCES**

R. E. MUSAFIR, J. G. SLAMA, and M. ZINDELUK (Rio de Janeiro, Universidade Federal, Brazil) IN: International Congress on Acoustic Intensity Measurement: Measurement Techniques and Applications, 2nd, Senlis, France, September 23-26, 1985, Proceedings. Senlis, France, Centre Technique des Industries Mecaniques, 1985, p. 407-412. refs

The usefulness of two-microphone acoustic-intensity (AI) measurements for characterizing the acoustic field of a jet flow is investigated by means of numerical simulations. The theoretical principles and data basis for the simulations are explained, and the intensity patterns generated by the simulation are presented graphically. It is found that the vector information in AI data from the near field are useful in understanding complex sources, but that far-field intensity charts cannot locate separate sources and may be misleading if not analyzed in terms of a sound physical model. T.K.

A86-48977#**THE AERODYNAMIC POTENTIAL OF ANTI-SOUND**

J. E. FLOWERS WILLIAMS (Cambridge University, England) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1-13. refs

This lecture discusses the interface between unsteady aerodynamics, flow stability and aeroacoustics. The central theme is the possibility of carrying over from acoustics some techniques of antisound to improve the performance of aeronautical systems. The lecture discusses the common basis for modeling weak unsteady flow perturbations and the areas which might be suitable for the application of controlled perturbations, deliberately created

to interfere destructively with some unwanted naturally occurring element. The development of aeroacoustic modeling is briefly surveyed to indicate the basis for the active control strategies, and the lecture concludes with examples of how these techniques have been applied at laboratory scale with distinctly promising results. Author

A86-49099#**METHOD FOR DETERMINATING THE ISO-NOISE LEVELS BY SIMULATED AIRCRAFT FLIGHT OPERATIONS**

A. SOBOR (ATAA Aeronautical Research Center, Budapest, Hungary) IN: ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 1168-1170.

Models are presented for the evaluation of perceived aircraft noise level as a function of aircraft position and time. The O-point in the engine noise emission coordinates was assumed to be permanently fixed at the aircraft's center of gravity. Changes in the noise characteristics were calculated as a function of the engine energy level, the Doppler effect, and the momentary distance between the aircraft and observer. Results of the adaptation of these models to noise in the vicinity of the Budapest-Ferihegy International Airport are indicated schematically. K.K.

A86-49566*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN APPROACH TO THE CALCULATION OF THE PRESSURE FIELD PRODUCED BY RIGID WIDE CHORD DUAL ROTATION PROPELLERS OF HIGH SOLIDITY IN COMPRESSIBLE FLOW

S. M. RAMACHANDRA and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-8, 1986. 41 p. Previously announced in STAR as N86-21517. refs

(AIAA PAPER 86-0467)

An unsteady lifting service theory for the counter-rotating propeller is presented using the linearized governing equations for the acceleration potential and representing the blades by a surface distribution of pulsating acoustic dipoles distributed according to a modified Birnbaum series. The Birnbaum series coefficients are determined by satisfying the surface tangency boundary conditions on the front and rear propeller blades. Expressions for the combined acoustic resonance modes of the front prop, the rear prop and the combination are also given. Author

A86-49575*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A STUDY OF HELICOPTER MAIN ROTOR NOISE IN HOVER

C. KITAPLIOGLU (NASA, Ames Research Center, Moffett Field, CA) and C. KINNEY (H. S. Robinson, Inc., San Carlos, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p.

(AIAA PAPER 86-1858)

Some fundamental aspects of rotor noise generation and radiation are presented. Data on which the study is based were obtained during a hover test at the NASA Ames Outdoor Aerodynamic Research Facility of a one-sixth-scale, four-bladed, helicopter rotor. The test site provided an open environment ideal for acquiring good acoustic data. Information is presented on the delineation between the acoustic near-field and far-field, and on the effect of a simple boundary-layer trip device. Data obtained at near-zero thrust conditions indicate that it is possible to isolate thickness noise with minimum contamination by loading noise effects. An abrupt change in the nature of the emitted noise at high-thrust conditions is investigated and is related to unsteady wake/support interaction. Author

A86-49716**TRUNCATED TAYLOR SERIES SOLUTIONS TO A GENERALIZED BURGERS' EQUATION**

G. P. HOWELL (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 108, July 8, 1986, p. 133-145. SERC-supported research. refs

A generalized Burgers' equation is solved in the frequency domain by deriving Taylor series expansions in powers of the range variable. The first five terms of the solution are derived, for both plane and spherical deterministic waveforms, for the boundary value problem of an arbitrary time history at the origin. Any frequency dependence of attenuation and dispersion is allowed. Particular solutions are found to agree with previous work on Burgers' equation. The errors involved in truncating both plane and spherical wave series are investigated, and a discussion of two special cases suggests a boundary to the domain in which such truncated solutions are useful; in particular, they are not well adapted to the prediction of high frequencies. Author

A86-49806*# Georgia Inst. of Tech., Atlanta.

AN ITERATIVE FINITE ELEMENT-INTEGRAL TECHNIQUE FOR PREDICTING SOUND RADIATION FROM TURBOFAN INLETS IN STEADY FLIGHT

S. J. HOROWITZ, R. K. SIGMAN, and B. T. ZINN (Georgia Institute of Technology, Atlanta) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1256-1262. Previously cited in issue 06, p. 812, Accession no. A82-17796. refs

(Contract NSG-3036)

N86-32249# Naval Underwater Systems Center, New London, Conn.

MEASUREMENT AND EXTRACTION OF RECURRING WAVEFORMS: FOR APPLICATIONS TO ACTIVE TRANSMISSIONS, FLOW-NOISE, AND HELICOPTER-RADIATED NOISE PROBLEMS

R. F. DWYER 24 Mar. 1986 39 p

(AD-A167400; NUSC-TM-861043) Avail: NTIS HC A03/MF A01 CSCL 20A

Physical acoustic sources that radiate transient waveforms represent a large class of noise generators. Active transmissions, flow-noise, and helicopter-radiated noise under certain flight situations depending on the source-observer orientation are members of this class. The objective of this paper is to present a signal processing methodology to extract time domain recurring waveforms from data. The recurring waveforms, on the one hand, may represent a source of interference that is to be eliminated as much as possible. But, on the other hand, these recurring waveforms may represent a desired signal that is to be extracted from a background of undesired noise. Both cases are shown in the paper to be different aspects of the same problem. Initially, the methodology is based on a physical property of equally spaced and identical recurring waveforms. These results are then generalized, because in practice, either by design or by other causes, the recurring waveforms may not be equally spaced and identical. The method is then applied to extract equally spaced and nearly identical waveforms which were produced by an approaching helicopter. Author (GRA)

N86-33125# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.

A COMPARISON BETWEEN ACOUSTIC MODE MEASUREMENTS AND ACOUSTIC FINITE ELEMENT ANALYSIS PERFORMED FOR SAAB SF 340

P. GOERANSSON and I. GREEN Mar. 1986 17 p Sponsored by Swedish Board for Technical Development (FFA-TN-1986-22; ETN-86-97234) Avail: NTIS HC A02/MF A01

In order to verify an acoustic finite element package, measured and calculated eigenmodes and eigenfrequencies for Saab SF 340 cabin acoustics were compared. The measurements were performed in an acoustic mockup. For the analysis, a two dimensional model of the cross section of the fuselage was used. The comparison shows quite good agreement, the discrepancies

being due to the representation of the flexible wall of the fuselage as rigid in the analysis. ESA

N86-33126# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.

ON THE WAY TO EXTENDED NOISE REDUCTIONS IN PROPELLER AIRCRAFT [OP WEG NAAR GROTERE GELUIDSREDUCTIES IN PROPELLER-VLIEGTUIGEN]

R. F. C. KIERS Aug. 1984 9 p In DUTCH; ENGLISH summary Presented at NLR Conference, Noordoostpolder, Netherlands, 6 Oct. 1983 Submitted for publication (B8573697; ETN-86-97502) Avail: NTIS HC A02/MF A01

Origins of cabin noise in propeller driven aircraft (PDE) and the importance of further reductions are described. Trends in propeller technology and fuselage construction are aimed at the development of extremely fuel-efficient PDE. However, the related increase of cabin noise levels urges the extension of noise reduction in PDE. Fokker noise reduction methodology for meeting the challenge of maintaining and improving noise levels in future PDE is discussed. Additional noise reduction is hard to obtain. Sophisticated techniques were used to acquire the necessary data and take effective noise reduction measures. ESA

17

SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A86-47617

CAN FUTURE AIRCRAFT MAINTENANCE BE AFFORDED?

H. W. SCHOEBERL (Austrian Airlines, Vienna, Austria) IN: AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports. Duesseldorf, West Germany, Duesseldorfer Messegesellschaft mbH, 1985, 7 p.

Ways of reducing airline operating costs are discussed. Cost planning and cost controlling are examined as parts of the management process, and operational, managerial, political/social, and geographical variables that influence maintenance costs are outlined. The use of technical cooperation and standardizing to hold down maintenance costs is addressed, and the importance of the careful choice of new aircraft in controlling costs is discussed. C.D.

A86-49571#

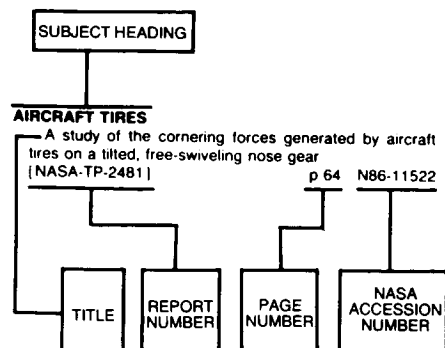
THE COMPETITIVE AND COOPERATIVE OUTLOOK FOR AIRCRAFT PROPULSION SYSTEMS

J. M. SCHOFIELD (United Technologies Corp., Commercial Products Div., East Hartford, CT) AIAA, Annual Meeting and International Aerospace Exhibit, Arlington, VA, Apr. 29-May 1, 1986. 12 p.

(AIAA PAPER 86-1134)

The advantages and disadvantages of coproduction of propulsion systems are examined. The international cooperation programs allow the transfer of technical knowledge, and risk and revenue sharing. The potential competition that may result from joint R&D programs is considered. Examples of successful coproduction projects, in particular those of the International Aero Engine consortium, are discussed. I.F.

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

A-300 AIRCRAFT

Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121

A-310 AIRCRAFT

Dynamic response of the A-310 in flight to control-surface loading [AAAF PAPER NT 85-18] p 797 A86-48467

A-320 AIRCRAFT

Airbus A 320 - New concept of aircraft control p 796 A86-47797

The high lift development of the A320 aircraft p 772 A86-49012

Anemobarometry in flight control. A-320 aerodynamics. The turboreactors air inlet [SNIAS-861-111-114] p 806 N86-31565

The A-320 aerodynamics. The turboreactor air inlet [NOTE-427.021/86] p 806 N86-31567

ACCELERATED LIFE TESTS

Engine control reliability and durability improvement through accelerated mission environmental testing [ASME PAPER 86-GT-52] p 813 A86-48132

ACCELERATION (PHYSICS)

Optimization and acceleration guidance of flight trajectories in a windshear [AIAA PAPER 86-2036] p 822 A86-47425

Acceleration performance of helicopter engines [ASME PAPER 86-GT-121] p 814 A86-48180

ACEE PROGRAM

Composites in today's and tomorrow's U.S. airliners p 841 A86-47603

ACOUSTIC ATTENUATION

The effect on the transmission loss of a double wall panel of using helium gas in the gap p 855 A86-48590

ACOUSTIC MEASUREMENT

Details of analysis of airplane structure acoustic loading in flight testing p 804 A86-49129

Airborne intruder detection considerations [DE86-006462] p 808 N86-31576

Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems [AD-A167400] p 856 N86-32249

ACOUSTIC PROPERTIES

An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow [AIAA PAPER 86-0467] p 856 A86-49566

ACTIVE CONTROL

Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft [AIAA PAPER 86-2243] p 824 A86-47491

Active flutter suppression p 832 A86-49004

Active control technology for civil transport p 832 A86-49005

Designing a load alleviation system for a modern civil aircraft p 832 A86-49006

Research on active suppression technology for wing/aileron flutter p 835 A86-49096

Active noise control --- in prop-fan aircraft cabins p 803 A86-49101

Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2 [NASA-CR-4014] p 836 N86-32440

ACTUATION

Aerodynamic delay following control actuation in a glider [AIAA PAPER 86-2226] p 829 A86-47689

ACTUATORS

On control concept for in-flight simulation including actuator nonlinearities and time delays [ESA-TT-948] p 836 N86-31593

Servo-actuator for sampled-data feedback disturbance rejection --- helicopters [DFVLR-FB-86-08] p 837 N86-32446

ADA (PROGRAMMING LANGUAGE)

RT-BUILD - Automatic generation of Ada code for flight control applications [AIAA PAPER 86-2088] p 852 A86-47439

ADAPTIVE CONTROL

Synthesis of an adaptive flight controller under unknown deterministic disturbances [AIAA PAPER 86-2157] p 823 A86-47464

An explicit adaptive flight control system based on the modified gain extended Kalman filter [AIAA PAPER 86-2158] p 823 A86-47465

Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control [AIAA PAPER 86-2017] p 826 A86-47652

A robust adaptive flightpath reconstruction technique [AIAA PAPER 80-2018] p 826 A86-47653

Boeing control law for CREST demonstration ejection seat p 794 A86-47758

Development of HIDECA adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278

Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter [SNIAS-861-210-108] p 836 N86-32444

ADAPTIVE FILTERS

Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495

ADHESIVE BONDING

Structural analysis of adhesive-bonded joints p 846 A86-47722

Adhesive-bonded aluminum structure repair p 846 A86-47725

ADHESIVES

Adhesive selection from the user's viewpoint p 841 A86-47715

Elevated-temperature-resistant adhesives p 842 A86-47717

AEROACOUSTICS

Acoustic effect on stall hysteresis for low Reynolds number laminar flow p 855 A86-47971

Broadband noise of propellers and rotors p 855 A86-48596

Modelling of acoustic radiation problems associated with turbomachinery and rotating blades p 855 A86-48597

The aerodynamic potential of anti-sound p 855 A86-48977

Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061

Details of analysis of airplane structure acoustic loading in flight testing p 804 A86-49129

A study of helicopter main rotor noise in hover [AIAA PAPER 86-1858] p 856 A86-49575

Noise control characteristics of synchrophasing. II - Experimental investigation --- on aircraft fuselage model p 805 A86-49808

AERODYNAMIC BALANCE

Studies for the application of a flexible weight and balance (W/B) measuring facility for commercial aircraft [BMFT-FB-W-85-029] p 840 N86-31604

AERODYNAMIC CHARACTERISTICS

Aerodynamics of delta wings with leading edge blowing [AIAA PAPER 86-2230] p 764 A86-47691

The dynamic response of a variable sweep aircraft in the course of changing geometry [AIAA PAPER 86-2234] p 829 A86-47694

Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model p 796 A86-47800

Particulate flow solutions through centrifugal impeller with two splitters [ASME PAPER 86-GT-130] p 765 A86-48188

Rotor-fuselage dynamic coupling characteristics of helicopter air and ground resonance p 799 A86-48666

Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769

Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779

Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783

Divergence of an anisotropic sweptforward wing p 768 A86-48788

Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807

Method for the visualization of subsonic gas flows p 769 A86-48808

Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809

Determination of off-design flowrates according to the position of branching points on an under-the-wing (over-the-wing) air intake p 769 A86-48812

Similarity criteria for a circulation control airfoil p 769 A86-48815

Determination of the aerodynamic characteristics of separated flow past a wing with allowance for slight unsteadiness induced by changes in angle of attack p 769 A86-48816

Transonic flow past the root section of a wing with sweepback and sweepforward p 769 A86-48817

Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838

An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen p 770 A86-48841

A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842

The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843

Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845

The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps p 771 A86-48849

Design of a supercritical airfoil p 771 A86-48892

- Validation on nonstationary aerodynamics models for
 longitudinal aeroplane motion on the basis of flight
 measurements p 833 A86-49026
- Prediction of the aerodynamic characteristics of flight
 vehicles in large unsteady maneuvers p 834 A86-49048
- Estimation of aerodynamic parameters from flight data
 of a high incidence research model p 834 A86-49057
- Method of analysing data on a swept wing aircraft in
 flight p 775 A86-49103
- An experimental study of a three lifting surface
 configuration p 775 A86-49104
- Oscillating wings and bodies with flexure in supersonic
 flow Applications of harmonic potential panel method
 p 776 A86-49108
- Prediction of gust loadings and alleviation at transonic
 speeds p 777 A86-49573
- [AIAA PAPER 86-0997] p 777 A86-49573
- High-angle-of-attack aerodynamics - Lessons learned
 [AIAA PAPER 86-1774] p 777 A86-49578
- Low-speed aerodynamics of apex fences on a tailless
 delta configuration p 779 A86-49593
- [AIAA PAPER 86-1838] p 779 A86-49593
- Low-speed aerodynamic characteristics of a 1/8-scale
 X-29A airplane model at high angles of attack and
 sideslip p 781 N86-31532
- [NASA-TM-87722] p 781 N86-31532
- The application of energy techniques to propeller-driven
 airplanes p 807 N86-31569
- [AD-A167113] p 807 N86-31569
- Aerodynamics of aircraft afterbody: Report of the
 working group on aerodynamics of aircraft afterbody
 [AGARD-AR-226] p 782 N86-32408
- A mathematical model of the Sea King Mk.50 helicopter
 aerodynamics and kinematics p 808 N86-32425
- [ARL-AERO-TM-379] p 808 N86-32425
- AERODYNAMIC CONFIGURATIONS**
- Unsteady low-speed aerodynamic model for complete
 aircraft configurations p 829 A86-47683
- [AIAA PAPER 86-2180] p 829 A86-47683
- Power level influence on architecture of small helicopter
 turboshaft engines p 815 A86-48241
- [ASME PAPER 86-GT-191] p 815 A86-48241
- Selecting the shape of the middle surface of the pylons
 and the mounting angles of single nacelles under the wing
 of subsonic aircraft p 800 A86-48767
- Transonic computations about complex configurations
 using coupled inner and outer flow equations p 771 A86-49008
- Application of the TranAir full-potential code to complete
 configurations p 772 A86-49009
- Precise solution for rational transfer parameters of flight
 vehicles p 801 A86-49022
- Algebraic grid generation about wing-fuselage bodies
 p 772 A86-49028
- Preliminary results of unsteady blade surface pressure
 measurements for the SR-3 propeller p 780 A86-49625
- [AIAA PAPER 86-1893] p 780 A86-49625
- Development of a data acquisition system to aid in the
 aerodynamic study of various helicopter configurations
 [AD-A167717] p 781 N86-31539
- Aerodynamic design methods for modern transport
 aircraft p 782 N86-31543
- [ESA-TT-923] p 782 N86-31543
- High speed viscous flow calculations about complex
 configurations p 850 N86-31827
- [NASA-TM-88237] p 850 N86-31827
- Aerodynamics of aircraft afterbody: Report of the
 working group on aerodynamics of aircraft afterbody
 [AGARD-AR-226] p 782 N86-32408
- AERODYNAMIC DRAG**
- Evaluation and reduction of drag p 766 A86-48452
- [AAAF PAPER NT 85-01] p 766 A86-48452
- The drag of a pair of bodies at supersonic flight
 velocities p 768 A86-48802
- Thick supercritical airfoils with low drag and NLF
 capability p 771 A86-48981
- Take-off prediction for the Airbus A300-600 and the A310
 compared with flight test results p 804 A86-49121
- Transonic wave drag estimation and optimization using
 the nonlinear area rule p 778 A86-49582
- [AIAA PAPER 86-1798] p 778 A86-49582
- AERODYNAMIC INTERFERENCE**
- Advances at AEDC in treating transonic wind tunnel wall
 interference p 839 A86-49058
- On the computation of wing lift interference caused by
 high bypass engines p 776 A86-49109
- Wing laminar boundary layer in the presence of a
 propeller slipstream p 776 A86-49122
- Transonic airfoil calculations including wind tunnel
 wall-interference effects p 780 A86-49825
- AERODYNAMIC LOADS**
- Vortex-induced effects on aircraft dynamics
 [AIAA PAPER 86-2279] p 830 A86-47697
- A new look at inflight loads on existing transport
 aircraft p 796 A86-47794
- Influence of rotor blade aerodynamic loading on the
 performance of a highly loaded turbine stage
 [ASME PAPER 86-GT-56] p 765 A86-48134
- Overview of helicopter wake and airloads technology
 p 767 A86-48654
- Calculation of the loading of the airframe in flight due
 to multidimensional turbulence p 799 A86-48759
- Determination of the required number of channels for
 controlling aircraft wing loading for several cases of
 calculation p 768 A86-48787
- Method for calculating pressure distribution on the
 surfaces of wings with slit mechanization p 768 A86-48806
- Active control technology for civil transport
 p 832 A86-49005
- Application of strain gauge methods to determination
 of in-flight loads of structure groups of small transport
 aircraft p 811 A86-49149
- AERODYNAMIC STABILITY**
- F-5E departure warning system algorithm development
 and validation p 830 A86-47702
- [AIAA PAPER 86-2284] p 830 A86-47702
- Numerical analysis of aeroelastic stability problem of
 helicopter rotor blade p 798 A86-48662
- Rotor aeroelastic stability p 798 A86-48664
- On the handling qualities of flight vehicles through
 variable flight conditions p 836 N86-31592
- [AD-A167727] p 836 N86-31592
- AERODYNAMIC STALLING**
- Visualization of dynamic stall controlled by large
 amplitude interrupted pitching motions p 764 A86-47699
- [AIAA PAPER 86-2281] p 764 A86-47699
- Acoustic effect on stall hysteresis for low Reynolds
 number laminar flow p 855 A86-47971
- Subsonic/transonic stall flutter investigation of an
 advanced low pressure compressor p 813 A86-48156
- [ASME PAPER 86-GT-90] p 813 A86-48156
- On the duration of low speed dynamic stall
 p 773 A86-49033
- Proposed control of compressor stall by pressure
 perturbation and blade design p 816 A86-49064
- A new, improved method for separating turbulent
 boundary layer for aerodynamic performance prediction
 of trailing edge stall airfoils p 779 A86-49590
- [AIAA PAPER 86-1832] p 779 A86-49590
- AERODYNAMICS**
- Atmospheric Flight Mechanics Conference,
 Williamsburg, VA, August 18-20, 1986, Technical Papers
 p 826 A86-47651
- Unsteady aerodynamics - Fundamental aspects and
 applications to aircraft dynamics p 767 A86-48465
- [AAAF PAPER NT 85-16] p 767 A86-48465
- The aerodynamic potential of anti-sound
 p 855 A86-48977
- International Aviation (selected articles) p 763 N86-31528
- [AD-A166298] p 763 N86-31528
- On the handling qualities of flight vehicles through
 variable flight conditions p 836 N86-31592
- [AD-A167727] p 836 N86-31592
- AEROELASTICITY**
- Real-time flutter identification with close mode
 resolution p 827 A86-47654
- [AIAA PAPER 86-2019] p 827 A86-47654
- On the flight dynamics of aeroelastic vehicles
 [AIAA PAPER 86-2077] p 828 A86-47666
- Modelling of rigid-body and elastic aircraft dynamics for
 flight control development p 829 A86-47693
- [AIAA PAPER 86-2232] p 829 A86-47693
- Computational engine structural analysis
 [ASME PAPER 86-GT-70] p 813 A86-48141
- Analytical and experimental investigation of the coupled
 bladed disk/shaft whirl of a cantilevered turbofan
 [ASME PAPER 86-GT-98] p 813 A86-48163
- Splitter blades as an aeroelastic detuning mechanism
 for uninstalled supersonic flutter of turbomachine rotors
 [ASME PAPER 86-GT-99] p 813 A86-48164
- Aeroelastic behavior of low aspect ratio metal and
 composite blades p 846 A86-48271
- [ASME PAPER 86-GT-243] p 846 A86-48271
- Numerical analysis of aeroelastic stability problem of
 helicopter rotor blade p 798 A86-48662
- Dynamic aspects in the design of advanced rotor
 systems p 798 A86-48663
- Rotor aeroelastic stability p 798 A86-48664
- Coupled aeroelastic hub loads reduction
 p 799 A86-48665
- Rotor-fuselage dynamic coupling characteristics of
 helicopter air and ground resonance p 799 A86-48666
- Implementation and verification of a comprehensive
 helicopter coupled rotor - Fuselage analysis
 p 799 A86-48667
- Oscillation equations for a helicopter rotor blade
 p 800 A86-48805
- Modeling the elasticity of a wing structure
 p 800 A86-48850
- Aeroelasticity today and tomorrow
 [ONERA, TP NO. 1986-105] p 800 A86-48978
- Aeroelastic tailoring for flutter constraints
 p 802 A86-49081
- A general formulation for the aeroelastic divergence of
 composite sweptforward wing structures p 802 A86-49095
- Research on active suppression technology for
 wing/aileron flutter p 835 A86-49096
- Aeroelastic tailoring of aft-swept high aspect ratio
 composite wings p 802 A86-49097
- Applications of potential theory computations to
 transonic aeroelasticity p 775 A86-49105
- Solid-beam model of a deformable aircraft for
 natural-vibration studies p 804 A86-49444
- Calculation of static elastic effects on a modern high
 performance fighter aircraft p 777 A86-49577
- [AIAA PAPER 86-1771] p 777 A86-49577
- Vortex influence on oscillating airfoil at high
 angle-of-attack p 779 A86-49592
- [AIAA PAPER 86-1837] p 779 A86-49592
- The development of aeroelastic tailoring in the United
 States p 805 A86-50111
- ATRAN3S: An unsteady transonic code for clean
 wings p 781 N86-31535
- [NASA-TM-86783] p 781 N86-31535
- An approach to integrated aeroservoelastic tailoring for
 stability p 836 N86-32439
- AERONAUTICAL ENGINEERING**
- The theoretical basis of helicopter technology;
 Proceedings of the Seminar, Nanjing, People's Republic
 of China, November 6-8, 1985, Parts 1, 2, 3, 4, & 5
 p 761 A86-48651
- Survivability considerations during aircraft conceptual
 design p 809 N86-32428
- [AD-A168555] p 809 N86-32428
- AERONAUTICS**
- Society of Flight Test Engineers, Annual Symposium,
 18th, Seattle, WA, July 29-August 2, 1985, Proceedings
 p 794 A86-47776
- ICAS, Congress, 15th, London, England, September
 7-12, 1986, Proceedings, Volumes 1 & 2 p 761 A86-48976
- AEROSPACE ENGINEERING**
- International Aerospace and Ground Conference on
 Lightning and Static Electricity, 10th, and Congress
 International Aeronautique, 17th, Paris, France, June
 10-13, 1985, Proceedings p 844 A86-47292
- Integrated structure/control design - Present
 methodology and future opportunities p 854 A86-49094
- AEROSPACE SCIENCES**
- ICAS, Congress, 15th, London, England, September
 7-12, 1986, Proceedings, Volumes 1 & 2 p 761 A86-48976
- AEROSPACE TECHNOLOGY TRANSFER**
- The impact of emerging technologies on an advanced
 supersonic transport p 761 A86-48997
- AEROTHERMODYNAMICS**
- Configuration and trajectory of hypersonic transport with
 aerothermodynamic control p 804 A86-49124
- AFTERBODIES**
- Intersection of an oblique shock wave with a cylindrical
 afterbody p 775 A86-49098
- Aerodynamics of aircraft afterbody: Report of the
 working group on aerodynamics of aircraft afterbody
 [AGARD-AR-226] p 782 N86-32408
- AGRICULTURAL AIRCRAFT**
- On the motion of spray drops in the wake of an
 agricultural aircraft p 777 A86-49441
- AH-64 HELICOPTER**
- Simulation evaluation of display/FLIR concepts for
 low-altitude, terrain-following helicopter operations
 [NASA-TM-86779] p 789 N86-31551
- AILERONS**
- Research on active suppression technology for
 wing/aileron flutter p 835 A86-49096
- AIR BREATHING BOOSTERS**
- A parametric study of a gas-generator airturbo ramjet
 (ATR) p 819 N86-31586
- [NASA-TM-88808] p 819 N86-31586
- AIR CARGO**
- Dynamics of a helicopter with a sling load
 [AIAA PAPER 86-2288] p 831 A86-47709
- AIR COOLING**
- Advanced concepts in small helicopter engine air-cooled
 turbine design p 819 A86-50075
- AIR DATA SYSTEMS**
- Flight testing on customer aircraft with a portable
 airborne digital data system p 810 A86-47788
- Avionics digital data acquisition system
 p 810 A86-47790
- From mainframe to micro - Structures and flutter testing
 at the Air Force Flight Test Center p 838 A86-47791
- Flight path reconstruction - A powerful tool for data
 compatibility check p 833 A86-49041

Smart probes for air data p 811 A86-49498

AIR FLOW
The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843

AIR INTAKES
Determination of off-design flowrates according to the position of branching points on an under-the-wing (over-the-wing) air intake p 789 A86-48812
Anemobarometry in flight control. A-320 aerodynamics. The turbochargers air inlet [SNIAS-861-111-114] p 806 N86-31585
The A-320 aerodynamics. The turbocharger air inlet [NOTE-427.021/86] p 806 N86-31587

AIR NAVIGATION
The INS wind calibration in climb algorithm p 796 A86-47799

AIR TO AIR MISSILES
Concept of automated aircraft guidance system for air-to-air missions [AIAA PAPER 86-2285] p 787 A86-47703

AIR TO AIR REFUELING
Aerial refueling evaluation of the CH-47D helicopter [AD-A167575] p 808 N86-31574

AIR TRAFFIC
Evaluation of alternatives for an Army precision landing system [AD-A167780] p 789 N86-31554

AIR TRAFFIC CONTROL
Design factors and considerations for a time-based flight management system [AIAA PAPER 86-2144] p 822 A86-47455
Secondary radar leads - Monopulse points the way p 787 A86-48372
Flight management concepts compatible with air traffic control p 788 A86-49018
A simulation facility for assessing the next generation of 4-D air traffic control procedures p 788 A86-49034
Airplane landing behaviors controlled by man-pilots p 835 A86-49244
Advanced ATC - An aircraft perspective p 788 A86-49637
A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations [ESA-TT-928] p 789 N86-31558

AIR TRAFFIC CONTROLLERS (PERSONNEL)
A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations [ESA-TT-928] p 789 N86-31558

AIRBORNE EQUIPMENT
Ranging and azimuthal problems of an airborne crossed loop used as a single-station lightning locator p 809 A86-47325
Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator [AIAA PAPER 86-2205] p 787 A86-47519
Flight testing on customer aircraft with a portable airborne digital data system p 810 A86-47788
Optimization of onboard systems of data acquisition and processing - Russian book p 810 A86-48531
Avionics fault data acquisition - A concept for civil transport aircraft p 810 A86-49051

AIRBORNE SURVEILLANCE RADAR
Air safety: Federal Aviation Administration's role in developing mid-air collision avoidance back-up systems [PB86-197506] p 787 N86-32418

AIRBORNE/SPACEBORNE COMPUTERS
Implications associated with the operation of digital data processing in the presence of the relatively harsh EMP environments produced by lightning p 809 A86-47319
Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 760 A86-47609
An artificial intelligence approach to onboard fault monitoring and diagnosis for aircraft applications [AIAA PAPER 86-2093] p 853 A86-48577
Smart probes for air data p 811 A86-49498
A knowledge-based expert system for scheduling of airborne astronomical observations p 854 A86-49627

AIRCRAFT ACCIDENT INVESTIGATION
The analysis of airline flight records for winds and performance with application to the Delta 191 accident [AIAA PAPER 86-2227] p 829 A86-47690
Angle-of-attack estimation for analysis of CAT encounters p 831 A86-47798

AIRCRAFT ACCIDENTS
Structural dynamics research in a full-scale transport aircraft crash test p 785 A86-49053

AIRCRAFT ANTENNAS
Corona threshold determination by three-stage physical modelling of aircraft p 792 A86-47333

AIRCRAFT APPROACH SPACING
Performance evaluation of a linear recursive technique for aircraft altitude prediction in airborne collision avoidance systems p 811 A86-49085

AIRCRAFT CARRIERS

Terminal control factors for the carrier landing task [AIAA PAPER 86-2251] p 825 A86-47497
Flight testing in the aircraft carrier environment p 794 A86-47779
Catapult holdback design examined p 838 A86-48041
Analysis of a mirror deck landing aid [AD-A167988] p 789 N86-31556

AIRCRAFT COMMUNICATION
Laser communication through low-visibility atmosphere for aircraft application p 788 A86-48581

AIRCRAFT COMPARTMENTS
Measurements and computer modelling of engine exhaust noise in the cabin of single-engine aircraft p 798 A86-48594
Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738
Control of interior noise in advanced turbopropeller aircraft p 802 A86-49100
Active noise control - in prop-fan aircraft cabins p 803 A86-49101
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies [AD-A167356] p 807 N86-31570
A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340 - propeller-driven aircraft [FFA-TN-1986-22] p 856 N86-33125

AIRCRAFT CONFIGURATIONS
Comparison of published HEMP and natural lightning on the surface of an aircraft - High-Altitude Electromagnetic Pulse p 783 A86-47293
Induced current surface density after a direct lightning strike on an aircraft p 790 A86-47297
Can Europe meet the challenge of LHX? p 797 A86-48370
Identification of unsteady response in rudders at low velocities [AAAF PAPER NT 85-19] p 797 A86-48468
Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48846
A review of unconventional aircraft design concepts p 801 A86-48995
Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044
An experimental study of a three lifting surface configuration p 775 A86-49104
Configuration and trajectory of hypersonic transport with aerothermodynamic control p 804 A86-49124
Validation of a full potential method for combined yaw and angle of attack [AIAA PAPER 86-1834] p 779 A86-49591
High speed viscous flow calculations about complex configurations [NASA-TM-88237] p 850 N86-31827
Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392

AIRCRAFT CONSTRUCTION MATERIALS
AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports p 759 A86-47601
A round-up on CFRP p 841 A86-47602
Composites in today's and tomorrow's U.S. airliners p 841 A86-47603
How one A/C manufacturer transits to composites p 759 A86-47604
Analysis of the costs and weight effects of CFK on air transport structure p 842 A86-48097
Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776
Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure p 785 A86-48989
Materials in aerospace - Can the emerging thermoplastics meet the challenge? p 843 A86-49020
Advanced polymer composites for high temperature applications p 843 A86-49021
Plastic or metal - The judgement factors - for selecting aircraft construction material p 762 A86-49037
Weight estimation techniques for composite airplanes in general aviation industry [NASA-CR-178163] p 781 N86-31531

AIRCRAFT CONTROL

Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers p 852 A86-47401
Aircraft control surface failure detection and isolation using the OSLR test - orthogonal series generalized likelihood ratio [AIAA PAPER 86-2028] p 821 A86-47419
Sensitivity analysis of high-order digital flight control systems using singular-value concepts [AIAA PAPER 86-2084] p 822 A86-47437
Rotary-wing aircraft terrain-following/terrain-avoidance system development [AIAA PAPER 86-2147] p 823 A86-47456
An explicit adaptive flight control system based on the modified gain extended Kalman filter [AIAA PAPER 86-2158] p 823 A86-47465
A design methodology for robust stabilizing controllers [AIAA PAPER 86-2195] p 823 A86-47475
A preliminary investigation of H (infinity) optimization [AIAA PAPER 86-2197] p 853 A86-47477
A controller for robust asymptotic tracking in systems with time-varying uncertainties [AIAA PAPER 86-2199] p 853 A86-47479
Effect of time delay on flying qualities - An update [AIAA PAPER 86-2202] p 823 A86-47482
Cooperative synthesis of control and display augmentation [AIAA PAPER 86-2204] p 853 A86-47484
Control reconfigurable combat aircraft flight control system development [AIAA PAPER 86-2236] p 824 A86-47488
Flight control system development and flight test experience with the F-111 mission adaptive wing aircraft [AIAA PAPER 86-2237] p 824 A86-47489
Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model [AIAA PAPER 86-2242] p 824 A86-47490
Model-following control for an oblique-wing aircraft [AIAA PAPER 86-2244] p 824 A86-47492
Terminal control factors for the carrier landing task [AIAA PAPER 86-2251] p 825 A86-47497
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors [AIAA PAPER 86-2030] p 810 A86-47511
NASA B737 flight test results of the Total Energy Control System [AIAA PAPER 86-2143] p 826 A86-47516
A fundamental approach to equivalent systems analysis - in evaluating aircraft handling qualities [AIAA PAPER 86-2128] p 828 A86-47674
The MIL-prime standard for aircraft flying qualities [AIAA PAPER 86-2131] p 828 A86-47677
Aerodynamic delay following control actuation in a glider [AIAA PAPER 86-2226] p 829 A86-47689
Stability and control of aircraft with manual all-moving tailplanes [AIAA PAPER 86-2231] p 829 A86-47692
Modelling of rigid-body and elastic aircraft dynamics for flight control development [AIAA PAPER 86-2232] p 829 A86-47693
Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack [AIAA PAPER 86-2277] p 830 A86-47695
Use of hinged strakes for lateral control at high angles of attack [AIAA PAPER 86-2278] p 830 A86-47696
Spherical mapping and analysis of aircraft angles for maneuvering flight [AIAA PAPER 86-2283] p 830 A86-47701
Boundary-layer transition effects on airplane stability and control [AIAA PAPER 86-2229] p 831 A86-47708
Precise control surface position measurements for hysteresis and twist testing p 795 A86-47789
Airbus A 320 - New concept of aircraft control p 796 A86-47797
An approach to an integrated control system for a modern fighter aircraft engine [ASME PAPER 86-GT-277] p 816 A86-48296
Determination of the required number of channels for controlling aircraft wing loading for several cases of calculation p 768 A86-48787
Determination of the statistical characteristics of aircraft motion during an automatic approach p 832 A86-48844
Influence of EFCS-control laws on structural design of modern transport aircraft p 800 A86-48984
Active control technology for civil transport p 832 A86-49005
Handling qualities for unstable combat aircraft p 833 A86-49025

Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control p 833 A86-49039

Forebody vortex management for yaw control at high angles of attack p 833 A86-49047

The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056

Optimal control laws for microburst encounter p 834 A86-49070

The M53 turbofan control system - A strong basis for the development of the future digital control systems p 817 A86-49088

Design of a nonlinear lever-type mechanism for aircraft control systems p 835 A86-49139

On the handling qualities of flight vehicles through variable flight conditions p 836 A86-31592

[AD-A167727] p 836 A86-31592

On control concept for in-flight simulation including actuator nonlinearities and time delays p 836 A86-31593

[ESA-TT-948] p 836 A86-31593

An approach to integrated aeroservoelastic tailoring for stability p 836 A86-32439

Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2 p 836 A86-32440

[NASA-CR-4014] p 836 A86-32440

AIRCRAFT DESIGN

How one A/C manufacturer transits to composites p 759 A86-47604

Ageing aircraft as seen by an authority p 783 A86-47611

Results of technology programs for general aviation aircraft at Domier p 795 A86-47787

T-46A - The USAF next generation trainer p 796 A86-47796

CFD for engine-airframe integration p 797 A86-48184

[ASME PAPER 86-GT-125] p 797 A86-48184

Fighter power for the 1990s p 816 A86-48369

Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767

Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830

Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845

Modeling the elasticity of a wing structure p 800 A86-48850

Aeroelasticity today and tomorrow p 800 A86-48978

[ONERA, TP NO. 1986-105] p 800 A86-48978

The race for speed from the beginning of aviation to the present day p 761 A86-48980

Design of a supercritical airfoil p 771 A86-48982

Influence of EFCS-control laws on structural design of modern transport aircraft p 800 A86-48984

747 modernization p 800 A86-48985

Applications of computer-aided engineering to subsonic aircraft design in a university environment p 801 A86-48986

Automated structural optimisation at Warton --- for aircraft p 854 A86-48987

A review of unconventional aircraft design concepts p 801 A86-48995

The British Aerospace Experimental Aircraft Programme and the role of system development cockpits p 801 A86-48996

The impact of emerging technologies on an advanced supersonic transport p 761 A86-48997

Lighter-than-air aircraft as control configured vehicle p 801 A86-48998

Active control technology for civil transport p 832 A86-49005

Optimum-Optimum integrated wing-fuselage configuration for supersonic transport aircraft of second generation p 801 A86-49010

The high lift development of the A320 aircraft p 772 A86-49012

Precise solution for rational transfer parameters of flight vehicles p 801 A86-49022

Validation on nonstationary aerodynamics models for longitudinal aeroplane motion on the basis of flight measurements p 833 A86-49026

Algebraic grid generation about wing-fuselage bodies p 772 A86-49028

Application of a full potential method to practical problems in supersonic aircraft design and analysis p 773 A86-49030

Certification of advanced experimental aircraft p 785 A86-49036

Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials p 762 A86-49067

Aeroelastic tailoring for flutter constraints p 802 A86-49081

Experimental investigation of electrostatic fire and explosion accidents after aircraft landing and preventive design p 786 A86-49083

Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094

Utilization of computation and experiment for airframe propulsion integration development p 803 A86-49110

New design procedures applied to landing gear development p 803 A86-49117

Topics in landing gear dynamics research at NASA Langley p 803 A86-49120

Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137

Design of a nonlinear lever-type mechanism for aircraft control systems p 835 A86-49139

Design bureaus: The brain drainers. I - Toulouse - Aircraft mobilize a task force over 1700-strong p 783 A86-49464

High-angle-of-attack aerodynamics - Lessons learned [AIAA PAPER 86-1774] p 777 A86-49578

Sounding a happy note for lift --- sound generation to prevent stalling p 780 A86-49676

Canard canard --- performance of light aircraft p 783 A86-49682

Wind tunnels battle the number-crunchers p 840 A86-49683

The development of aeroelastic tailoring in the United States p 805 A86-50111

F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259

Laminar flow research applicable to subsonic aircraft p 781 A86-50269

Aerodynamic design methods for modern transport aircraft p 782 A86-31543

[ESA-TT-923] p 782 A86-31543

Advisory Circular: Design considerations to protect fuel systems during a wheels-up landing p 806 A86-31564

[FAA-AC/25.994-1] p 806 A86-31564

Anemometry in flight control. A-320 aerodynamics. The turbochargers air inlet p 806 A86-31565

[SNIAS-861-111-114] p 806 A86-31565

The A-320 aerodynamics. The turbocharger air inlet [NOTE-427.021/86] p 806 A86-31567

Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2 p 808 A86-31577

[BMFT-FB-W-85-022] p 808 A86-31577

New technology propulsion (ANT) for general aviation aircraft, phase 1 p 820 A86-31589

[BMFT-FB-W-85-031] p 820 A86-31589

Aerodynamics of aircraft afterbody: Report of the working group on aerodynamics of aircraft afterbody p 782 A86-32408

[AGARD-AR-226] p 782 A86-32408

Survivability considerations during aircraft conceptual design p 809 A86-32428

[AD-A168555] p 809 A86-32428

The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques --- aircraft design p 809 A86-32430

[NLR-TR-85014-U] p 809 A86-32430

Recent developments in propulsion aerodynamics p 820 A86-32437

[NLR-MP-85031-U] p 820 A86-32437

Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners) p 851 A86-32784

[SNIAS-436.021/85] p 851 A86-32784

Simulation and optimization techniques in computer aided design p 854 A86-33053

[NLR-MP-85022-U] p 854 A86-33053

An infrastructure for information processing for computer aided design p 854 A86-33054

[NLR-MP-85038-U] p 854 A86-33054

AIRCRAFT ENGINES

The use of surface static pressure data as a diagnostic tool in multistage compressor development p 812 A86-48103

[ASME PAPER 86-GT-3] p 812 A86-48103

Engine component life prediction methodology for conceptual design investigations p 812 A86-48116

[ASME PAPER 86-GT-24] p 812 A86-48116

Life cycle cost methodology for preliminary design evaluation p 812 A86-48124

[ASME PAPER 86-GT-37] p 812 A86-48124

Heat management in advanced aircraft gas turbine engines p 813 A86-48144

[ASME PAPER 86-GT-76] p 813 A86-48144

Comparison of methods for lifetime calculations of highly loaded aero-engine discs p 814 A86-48165

[ASME PAPER 86-GT-102] p 814 A86-48165

A study on NOx emissions from gas turbine combustor p 814 A86-48220

[ASME PAPER 86-GT-168] p 814 A86-48220

A general computational method for simulation and prediction of transient behavior of gas turbines p 815 A86-48230

[ASME PAPER 86-GT-180] p 815 A86-48230

Stratified charge rotary engine for general aviation p 815 A86-48231

[ASME PAPER 86-GT-181] p 815 A86-48231

Fuel effects on aircraft combustor emissions p 815 A86-48252

[ASME PAPER 86-GT-212] p 815 A86-48252

An approach to an integrated control system for a modern fighter aircraft engine p 816 A86-48296

[ASME PAPER 86-GT-277] p 816 A86-48296

Aircraft/engine integration for an advanced fighter considering mission specifics p 797 A86-48308

[ASME PAPER 86-GT-295] p 797 A86-48308

Engine condition monitoring at KLM Royal Dutch Airlines p 816 A86-48312

[ASME PAPER 86-GT-300] p 816 A86-48312

Fighter power for the 1990s p 816 A86-48369

Future trends in propulsion p 816 A86-48979

Single crystal superalloys for turbine blades in advanced aircraft engines p 843 A86-49077

[ONERA, TP NO. 1986-102] p 843 A86-49077

Potential application of advanced propulsion systems to civil aircraft p 802 A86-49093

On the computation of wing lift interference caused by high bypass engines p 776 A86-49109

Theoretical considerations of the specific impulse of ramjet engines p 817 A86-49111

A comparison of pod and tail mounted ramjets p 818 A86-49112

Unified constitutive materials model development and evaluation for high-temperature structural analysis applications --- for aircraft gas turbine engines p 849 A86-49133

Contactless measurement of the torque of an aircraft engine p 849 A86-49145

The competitive and cooperative outlook for aircraft propulsion systems p 857 A86-49571

[AIAA PAPER 86-1134] p 857 A86-49571

An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography p 844 A86-49964

The application of energy techniques to propeller-driven airplanes p 807 A86-31569

[AD-A167113] p 807 A86-31569

An overview of the Small Engine Component Technology (SECT) studies p 819 A86-31587

[NASA-TM-88796] p 819 A86-31587

Development of a takeoff performance monitoring system p 835 A86-31591

[NASA-TM-89001] p 835 A86-31591

Cost reductions from introduction of new life philosophies for aircraft engine discs p 820 A86-32438

[NLR-MP-85076-U] p 820 A86-32438

AIRCRAFT FUELS

Thermal decomposition of aircraft fuel p 842 A86-48123

[ASME PAPER 86-GT-36] p 842 A86-48123

Thermal stability concerns of Navy aviation fuel p 842 A86-48159

[ASME PAPER 86-GT-94] p 842 A86-48159

The performance of a reverse flow combustor using JP 10 fuel p 814 A86-48202

[ASME PAPER 86-GT-146] p 814 A86-48202

Fuel effects on aircraft combustor emissions p 815 A86-48252

[ASME PAPER 86-GT-212] p 815 A86-48252

Impact of higher freeze point fuels on naval aircraft operations p 843 A86-48285

[ASME PAPER 86-GT-262] p 843 A86-48285

Advisory Circular: Design considerations to protect fuel systems during a wheels-up landing p 806 A86-31564

[FAA-AC/25.994-1] p 806 A86-31564

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests p 807 A86-31573

[AD-A167445] p 807 A86-31573

Aerial refueling evaluation of the CH-47D helicopter p 808 A86-31574

[AD-A167575] p 808 A86-31574

AIRCRAFT GUIDANCE

Concept of automated aircraft guidance system for air-to-air missions p 787 A86-47703

[AIAA PAPER 86-2285] p 787 A86-47703

Optimization and gamma/theta guidance of flight trajectories in a windshear p 834 A86-49071

AIRCRAFT HAZARDS

Comparison of published HEMP and natural lightning on the surface of an aircraft --- High-Altitude Electromagnetic Pulse p 783 A86-47293

Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295

Induced current surface density after a direct lightning strike on an aircraft p 790 A86-47297

Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299

Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305

Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307

Optical detection methods for testing of fuel tank lightning ignition hazards p 791 A86-47309

High voltage laboratory tests and lightning phenomena p 844 A86-47312

- The energy requirements of an aircraft triggered discharge p 844 A86-47315
- Aircraft lightning attachment at low altitudes p 791 A86-47317
- Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318
- Lightning-induced transient test on a transport aircraft p 791 A86-47327
- Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331
- The risk of collision in a two seat aircraft ejection p 783 A86-47730
- NASA's aircraft icing analysis program p 786 A86-49107
- Aircraft protection against lightning strikes p 806 A86-50347
- NASA's Aircraft Icing Analysis Program [NASA-TM-88791] p 786 N86-31548
- Fireproof hydraulic brake system [AD-A167774] p 786 N86-31549
- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies [AD-A167356] p 807 N86-31570
- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary [AD-A167443] p 807 N86-31571
- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants [AD-A167444] p 807 N86-31572
- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests [AD-A167445] p 807 N86-31573
- AIRCRAFT HYDRAULIC SYSTEMS**
- Pumps for 8000 psi hydraulic systems examined p 846 A86-48042
- AIRCRAFT INDUSTRY**
- Case studies in aircraft manufacturing automation p 782 A86-49000
- AIRCRAFT INSTRUMENTS**
- Aircraft lightning attachment at low altitudes p 791 A86-47317
- Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318
- A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy [AIAA PAPER 86-2029] p 809 A86-47420
- Strain-gauge autopilot altitude corrector p 811 A86-49142
- Anemobarometry: An essential element of flight control p 835 A86-31566
- The application of energy techniques to propeller-driven airplanes [AD-A167113] p 807 N86-31569
- AIRCRAFT LANDING**
- Terminal control factors for the carrier landing task [AIAA PAPER 86-2251] p 825 A86-47497
- Use of flight simulation to develop terminal instrument procedures for transport category aircraft [AIAA PAPER 86-2072] p 837 A86-47662
- Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672
- Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676
- Optimal landing of a helicopter in autorotation [AIAA PAPER 86-2287] p 793 A86-47705
- Effects of time delay and pitch control sensitivity in the flared landing [AIAA PAPER 86-2075] p 831 A86-47706
- The ground effects of a powered-lift STOL aircraft during landing approach p 795 A86-47784
- Analysis and simulation of the MLS landing signal - Echo separation - French thesis p 788 A86-48564
- Take-off and landing in a downburst p 786 A86-49069
- Measurements of landing gear loads of a commuter airliner p 803 A86-49119
- Airplane landing behaviors controlled by man-pilots p 835 A86-49244
- Fireproof hydraulic brake system [AD-A167774] p 786 N86-31549
- Portable glide slope indicator [AD-D012240] p 789 N86-31552
- Analysis of a mirror deck landing aid [AD-A167988] p 789 N86-31556
- Investigations in landing process of aircraft by means of the Monte-Carlo method [ESA-TT-951] p 808 N86-31578
- AIRCRAFT LAUNCHING DEVICES**
- Catapult holdback design examined p 838 A86-48041
- AIRCRAFT MAINTENANCE**
- Supplemental inspections of aging aircraft p 845 A86-47525
- Analytical applications in the Army oil analysis program p 845 A86-47595
- AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseeldorf, West Germany, February 26-March 3, 1985, Conference Reports p 759 A86-47601
- Potential of BITE's and what it means to aircraft maintenance p 759 A86-47607
- Working with today's BITE - One airline's experience p 759 A86-47608
- Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 780 A86-47609
- Practical implementation of a maintenance and engineering system in an airline p 760 A86-47610
- Aging aircraft as seen by an authority p 783 A86-47611
- Early corrosion detection and prevention measures - for aircraft p 780 A86-47612
- Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing p 845 A86-47613
- Stripping and painting a plane - Technological and economic aspects p 760 A86-47614
- Aircraft maintenance in China - Approaches to modernization p 760 A86-47615
- Planning for minimum overhaul time p 760 A86-47616
- Can future aircraft maintenance be afforded? p 857 A86-47617
- Adhesive-bonded aluminum structure repair p 846 A86-47725
- Power turbine vane ring (PT6 engine) repair development [ASME PAPER 86-GT-2] p 812 A86-48102
- Durability and damage tolerance assessment of the TF34-100 engine [ASME PAPER 86-GT-38] p 812 A86-48125
- Fabrication of high-alumina ceramic fixtures for jet engine repair applications [ASME PAPER 86-GT-46] p 846 A86-48130
- Use and maintenance of helicopters on the plateau - areas of China p 785 A86-48669
- Avionics fault data acquisition - A concept for civil transport aircraft p 810 A86-49051
- Maintainability optimization - The future challenge - for aircraft maintenance p 762 A86-49052
- On the fast repair of aircraft panel components p 762 A86-49066
- AIRCRAFT MANEUVERS**
- Spherical mapping and analysis of aircraft angles for maneuvering flight [AIAA PAPER 86-2283] p 830 A86-47701
- Prediction of the aerodynamic characteristics of flight vehicles in large unsteady maneuvers p 834 A86-49048
- A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425
- AIRCRAFT MODELS**
- Corona threshold determination by three-stage physical modelling of aircraft p 792 A86-47333
- Unsteady low-speed aerodynamic model for complete aircraft configurations [AIAA PAPER 86-2180] p 829 A86-47683
- Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model p 796 A86-47800
- Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
- The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833
- Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057
- Wind tunnels battle the number-crunchers p 840 A86-49683
- KRASH 85 user's guide: Input/output format, revision [AD-A168846] p 787 N86-32416
- AIRCRAFT NOISE**
- The effect on the transmission loss of a double wall panel of using helium gas in the gap p 855 A86-48590
- Measurements and computer modelling of engine exhaust noise in the cabin of single-engine aircraft p 796 A86-48594
- Area equivalent method (AEM) on VISICALC and LOTUS 1-2-3 - The Federal Aviation Administration's spreadsheet programs for predicting noise exposure contour areas around an airport p 853 A86-48595
- Broadband noise of propellers and rotors p 855 A86-48596
- Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738
- The aerodynamic potential of anti-sound p 855 A86-48977
- Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061
- Method for determining the ISO-noise levels by simulated aircraft flight operations p 856 A86-49099
- Control of interior noise in advanced turbopropeller aircraft p 802 A86-49100
- Active noise control - in prop-fan aircraft cabins p 803 A86-49101
- A study of helicopter main rotor noise in hover [AIAA PAPER 86-1858] p 856 A86-49575
- Truncated Taylor series solutions to a generalized Burgers' equation p 856 A86-49716
- New technology propulsion (ANT) for general aviation aircraft, phase 1 [BMFT-FB-W-85-031] p 820 N86-31589
- Airport noise control strategies [AD-A167877] p 840 N86-31602
- Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems [AD-A167400] p 856 N86-32249
- A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340 - propeller-driven aircraft [FFA-TN-1986-22] p 856 N86-33125
- AIRCRAFT PERFORMANCE**
- A methodology for evaluating the operational performance of an aircraft in a tactical environment [AIAA PAPER 86-2095] p 759 A86-47444
- Design factors and considerations for a time-based flight management system [AIAA PAPER 86-2144] p 822 A86-47455
- Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672
- The effect of heave damping (ZW) on helicopter handling qualities [AIAA PAPER 86-2129] p 828 A86-47675
- Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676
- The MIL-prime standard for aircraft flying qualities [AIAA PAPER 86-2131] p 828 A86-47677
- The analysis of airline flight records for winds and performance with application to the Delta 191 accident [AIAA PAPER 86-2227] p 829 A86-47690
- Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985, Proceedings p 794 A86-47776
- The ground effects of a powered-lift STOL aircraft during landing approach p 795 A86-47784
- Flight testing on customer aircraft with a portable airborne digital data system p 810 A86-47786
- A new look at inflight loads on existing transport aircraft p 796 A86-47794
- Self-oscillatory regimes of aircraft motion during spin-roll coupling p 832 A86-48775
- The race for speed from the beginning of aviation to the present day p 761 A86-48980
- Wind influence on the range of jet or propeller aircraft p 801 A86-48990
- A review of unconventional aircraft design concepts p 801 A86-48995
- The British Aerospace Experimental Aircraft Programme and the role of system development cockpits p 801 A86-48996
- Long endurance aircraft performance p 805 A86-49478
- Development of a takeoff performance monitoring system [NASA-TM-89001] p 835 N86-31591
- AIRCRAFT PILOTS**
- Identification of pilot dynamics in a system with a choice of feedback structures [AIAA PAPER 86-2250] p 825 A86-47496
- Airplane landing behaviors controlled by man-pilots p 835 A86-49244
- AIRCRAFT PRODUCTION**
- How one A/C manufacturer transits to composites p 759 A86-47804
- Case studies in aircraft manufacturing automation p 762 A86-49000

The competitive and cooperative outlook for aircraft propulsion systems
[AIAA PAPER 86-1134] p 857 A86-49571

AIRCRAFT PRODUCTION COSTS
Manufacturers seek reduced costs through new fabrication techniques p 762 A86-49448

AIRCRAFT RELIABILITY
Single-state observer design considerations for aircraft application
[AIAA PAPER 86-1996] p 852 A86-47418
A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy
[AIAA PAPER 86-2029] p 809 A86-47420
Robust fault detection and isolation for a high performance aircraft on STOL approach
[AIAA PAPER 86-2031] p 821 A86-47421
A methodology for evaluating the operational performance of an aircraft in a tactical environment
[AIAA PAPER 86-2095] p 759 A86-47444
AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseeldorf, West Germany, February 26-March 3, 1985, Conference Reports p 759 A86-47601
Ageing aircraft as seen by an authority p 783 A86-47611
Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing p 845 A86-47613
Engine control reliability and durability improvement through accelerated mission environmental testing
[ASME PAPER 86-GT-52] p 813 A86-48132
Managing airworthiness p 785 A86-49035
A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054
A contribution to airworthiness certification of gas turbine disks p 849 A86-49136
Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137
Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve p 804 A86-49138
An analytical methodology for predicting repair time distributions of advanced technology aircraft
[AD-A167149] p 763 N86-31529
Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program
[NLR-MP-84023-U] p 811 N86-32431

AIRCRAFT SAFETY
Aspects of lightning protection schemes for radomes p 792 A86-47338
F-5E departure warning system algorithm development and validation
[AIAA PAPER 86-2284] p 830 A86-47702
Flow stagnation as an advanced windblast protection technique --- for ejection seat safety p 793 A86-47727
Evaluation of a pre-ejection upper torso retraction device p 793 A86-47728
Scott emergency escape breathing device - Evaluation for use in Canadian forces aircraft p 784 A86-47731
Development of a controllable catapult for ejection seats p 793 A86-47733
Retrofit energy-absorbing crewseat for the SH-3 (S-61 series) Sea King helicopter p 793 A86-47736
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738
Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743
Advancements in inertia reels for fixed seating aircraft p 784 A86-47744
Emergency underwater escape from helicopters p 784 A86-47745
Concept development of a canopy escape module p 784 A86-47759
Development of a new lightweight emergency escape breathing device p 784 A86-47760
Aircrew protection design, training and mission management for high altitude aerodynamic operations p 761 A86-47778
Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure p 785 A86-48989
Managing airworthiness p 785 A86-49035
Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055
The airline engineering role in the management of safety p 762 A86-49084
Aircraft protection against lightning strikes p 806 A86-50347
Advisory Circular: Design considerations to protect fuel systems during a wheels-up landing
[FAA-AC/25.994-1] p 806 N86-31564

Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2 [ETN-86-97395] p 811 N86-31581
Air safety: Federal Aviation Administration's role in developing mid-air collision avoidance back-up systems [PB86-197506] p 787 N86-32418

AIRCRAFT SPIN
F-5E departure warning system algorithm development and validation
[AIAA PAPER 86-2284] p 830 A86-47702

AIRCRAFT STABILITY
Limitations of statically unstable aircraft due to the effects of sensor noise, turbulence, and structural dynamics
[AIAA PAPER 86-2203] p 824 A86-47483
Real-time flutter identification with close mode resolution
[AIAA PAPER 86-2019] p 827 A86-47654
Application of parameter estimation to highly unstable aircraft
[AIAA PAPER 86-2020] p 827 A86-47655
On the flight dynamics of aeroelastic vehicles
[AIAA PAPER 86-2077] p 828 A86-47666
Stability and control of aircraft with manual all-moving tailplanes
[AIAA PAPER 86-2231] p 829 A86-47692
Boundary-layer transition effects on airplane stability and control
[AIAA PAPER 86-2229] p 831 A86-47708
Identification of unsteady response in rudders at low velocities
[AAAF PAPER NT 85-19] p 797 A86-48468
Overview of helicopter wake and airloads technology p 767 A86-48654
A study of stability and control of a hingeless rotor helicopter with non-uniform induced velocity field p 831 A86-48655
Rotor aeroelastic stability p 798 A86-48864
The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671
Design criteria for flight control systems p 833 A86-49023
Handling qualities for unstable combat aircraft p 833 A86-49025
The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056
An approach to integrated aeroservoelastic tailoring for stability p 836 N86-32439

AIRCRAFT STRUCTURES
Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296
Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection p 845 A86-47329
Early corrosion detection and prevention measures --- for aircraft p 760 A86-47612
Adhesive selection from the user's viewpoint p 841 A86-47715
Environmental-durability testing --- of Al alloy bonded aircraft structures p 845 A86-47719
Chemical analysis for control --- of Al alloy aircraft structures p 842 A86-47720
Coatings --- for Al alloy corrosion control p 845 A86-47721
Structural analysis of adhesive-bonded joints p 846 A86-47722
Adhesive-bonded aluminum structure repair p 846 A86-47725
From mainframe to micro - Structures and flutter testing at the Air Force Flight Test Center p 838 A86-47791
Computing codes for development of helicopter crashworthy structures and test substantiation p 798 A86-48657
Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760
Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48846
Automated structural optimisation at Warton --- for aircraft p 854 A86-48987
Fibre optic damage detection in composite structures p 848 A86-48988
Airbus-assembly concepts to improve productivity and flexibility in aircraft construction p 761 A86-48999
Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003
On the fast repair of aircraft panel components p 762 A86-49066

The control and use of residual stresses in aircraft structural parts p 849 A86-49114
Some aspects of the reliability analysis of aircraft structures p 849 A86-49127
Details of analysis of airplane structure acoustic loading in flight testing p 804 A86-49129
Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137
Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve p 804 A86-49138
Application of strain gauge amplifiers and computer technology to the strength testing of aircraft p 849 A86-49144
Application of strain gauge methods to determination of in-flight loads of structure groups of small transport aircraft p 811 A86-49149
Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear --- Russian book p 804 A86-49288
Solid-beam model of a deformable aircraft for natural-vibration studies p 804 A86-49444
Structural design and analysis aspects of composite helicopter components [MBB-UD-454-85-OE] p 806 A86-50256
Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AD-A167717] p 781 N86-31539
Dynamic analysis: Correlation of theory with experiment --- MSC/NASTRAN analysis of Westland 30 G-BGHF [RP661] p 851 N86-31917
The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques --- aircraft design p 809 N86-32430
Review of aeronautical fatigue investigations in the Netherlands during the period March 1983 - February 1985 p 851 N86-32779
[NLR-MP-85025-U] p 851 N86-32779
Short cracks in aerospace structures [NLR-MP-85054-U] p 851 N86-32781

AIRCRAFT SURVIVABILITY
A methodology for evaluating the operational performance of an aircraft in a tactical environment
[AIAA PAPER 86-2095] p 759 A86-47444
Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760
Survivability considerations during aircraft conceptual design [AD-A168555] p 809 N86-32428

AIRCRAFT TIRES
A certain type of self-oscillation of aircraft landing-gear wheels p 800 A86-48829
Shimmy problems of landing gears caused by elastic deformation of tires p 803 A86-49118

AIRCRAFT WAKES
Control of wake structure behind an oscillating airfoil [AIAA PAPER 86-2282] p 764 A86-47700
The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671
Wake/boundary-layer interactions in two and three dimensions p 773 A86-49032
On the motion of spray drops in the wake of an agricultural aircraft p 777 A86-49441

AIRFIELD SURFACE MOVEMENTS
Shimmy problems of landing gears caused by elastic deformation of tires p 803 A86-49118

AIRFOIL FENCES
Low-speed aerodynamics of apex fences on a tailless delta configuration [AIAA PAPER 86-1836] p 779 A86-49593

AIRFOIL PROFILES
Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme p 769 A86-48822
The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps p 771 A86-48849
Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
Trapping of a free vortex by airfoils with surface suction p 780 A86-49801
Airfoil trailing-edge flow measurements p 780 A86-49803
Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB) [ESA-T-916-PT-2] p 782 N86-31542

AIRFOILS
Visualization of dynamic stall controlled by large amplitude interrupted pitching motions [AIAA PAPER 86-2281] p 764 A86-47699
Control of wake structure behind an oscillating airfoil [AIAA PAPER 86-2282] p 764 A86-47700
Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659

- Potential flow models of airfoils with separated flow
p 772 A86-49013
- An experimental study of turbulent wake/boundary layer
mixing flows p 772 A86-49014
- Wake/boundary-layer interactions in two and three
dimensions p 773 A86-49032
- On the duration of low speed dynamic stall
p 773 A86-49033
- An entropy correction method for unsteady full potential
flows with strong shocks p 777 A86-49576
[AIAA PAPER 86-1768]
- Calculation of 2-D unsteady transonic full potential flow
about oscillating airfoils by two complementary
approaches p 778 A86-49586
[AIAA PAPER 86-1821]
- A new, improved method for separating turbulent
boundary layer for aerodynamic performance prediction
of trailing edge stall airfoils p 779 A86-49590
[AIAA PAPER 86-1832]
- Vortex influence on oscillating airfoil at high
angle-of-attack p 779 A86-49592
[AIAA PAPER 86-1837]
- Sounding a happy note for lift — sound generation to
prevent stalling p 780 A86-49676
- Transonic airfoil calculations including wind tunnel
wall-interference effects p 780 A86-49825
- AIRFRAMES**
- Finite element analysis and optimum design of
semi-monocoque airframe structures. I - Finite element
analysis p 847 A86-48656
- Calculation of the loading of the airframe in flight due
to multidimensional turbulence p 799 A86-48759
- The British Aerospace Experimental Aircraft Programme
and the role of system development cockpits p 801 A86-48996
- Experience with stress analysis during airframe fatigue
tests p 840 A86-49143
- Manufacturers seek reduced costs through new
fabrication techniques p 762 A86-49448
- Low mass diffusion bonding tools
[AD-D012295] p 851 N86-32746
- AIRLINE OPERATIONS**
- Practical implementation of a maintenance and
engineering system in an airline p 760 A86-47610
- Planning for minimum overhaul time p 760 A86-47616
- Can future aircraft maintenance be afforded?
p 857 A86-47617
- Engine condition monitoring at KLM Royal Dutch
Airlines p 816 A86-48312
[ASME PAPER 86-GT-300]
- Flight management concepts compatible with air traffic
control p 788 A86-49018
- The airline engineering role in the management of
safety p 762 A86-49084
- AIRPORT BEACONS**
- Portable glide slope indicator
[AD-D012240] p 789 N86-31552
- AIRPORT PLANNING**
- Airports build for future traffic amid new security
concern p 838 A86-48371
- AIRPORT SECURITY**
- Airports build for future traffic amid new security
concern p 838 A86-48371
- AIRPORTS**
- Area equivalent method (AEM) on VISICALC and LOTUS
1-2-3 - The Federal Aviation Administration's spreadsheet
programs for predicting noise exposure contour areas
around an airport p 853 A86-48595
- Calculating method for Z - 9 helicopters mooring load
p 799 A86-48668
- Airport noise control strategies
[AD-A167977] p 840 N86-31602
- AIRSHIPS**
- Lighter-than-air aircraft as control configured vehicle
p 801 A86-48998
- AIRSPACE**
- Airborne intruder detection considerations
[DE86-006462] p 808 N86-31576
- AIRSPEED**
- The race for speed from the beginning of aviation to
the present day p 761 A86-48980
- ALGORITHMS**
- Development of a takeoff performance monitoring
system p 835 N86-31591
[NASA-TM-89001]
- High speed viscous flow calculations about complex
configurations p 850 N86-31827
[NASA-TM-88237]
- Active control of helicopter vibrations. Flight evaluation
of a vibration reduction system on a Gazelle SA 349
helicopter p 836 N86-32444
[SNIAS-861-210-108]
- ALIGNMENT**
- Simulator scene display evaluation device
[NASA-CASE-ARC-11504-1] p 840 N86-32447
- ALL-WEATHER AIR NAVIGATION**
- Flight testing of the Tornado Terrain Following Radar
System in bad weather p 795 A86-47783
- ALL-WEATHER LANDING SYSTEMS**
- An all-weather multimode landing system for tactical
fighter aircraft p 787 A86-47517
[AIAA PAPER 86-2146]
- ALTIMETERS**
- Strain-gauge autopilot altitude corrector
p 811 A86-49142
- Anemobarometry in flight control. A-320 aerodynamics.
The turboreactors air inlet p 806 N86-31565
[SNIAS-861-111-114]
- Anemobarometry: An essential element of flight
control p 835 N86-31566
- ALTIMETRY**
- Characteristics of altitude error at reduced
quantization p 811 N86-31580
[FAA/PM-86/35]
- ALTITUDE CONTROL**
- Identification of pilot dynamics in a system with a choice
of feedback structures p 825 A86-47496
[AIAA PAPER 86-2250]
- Performance evaluation of a linear recursive technique
for aircraft altitude prediction in airborn collision avoidance
systems p 811 A86-49085
- Strain-gauge autopilot altitude corrector
p 811 A86-49142
- ALUMINUM ALLOYS**
- Adhesive selection from the user's viewpoint
p 841 A86-47715
- Elevated-temperature-resistant adhesives
p 842 A86-47717
- Environmental-durability testing --- of Al alloy bonded
aircraft structures p 845 A86-47719
- Chemical analysis for control --- of Al alloy aircraft
structures p 842 A86-47720
- Coatings --- for Al alloy corrosion control
p 845 A86-47721
- Adhesive-bonded aluminum structure repair
p 846 A86-47725
- The control and use of residual stresses in aircraft
structural parts p 849 A86-49114
- ALUMINUM OXIDES**
- Fabrication of high-alumina ceramic fixtures for jet
engine repair applications p 846 A86-48130
[ASME PAPER 86-GT-46]
- AMPHIBIOUS AIRCRAFT**
- Technology demonstration for investigation of the new
possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577
- AMPLIFIER DESIGN**
- Application of strain gauge amplifiers and computer
technology to the strength testing of aircraft
p 849 A86-49144
- ANALOG COMPUTERS**
- Implications associated with the operation of digital data
processing in the presence of the relatively harsh EMP
environments produced by lightning p 809 A86-47319
- ANALOG SIMULATION**
- The use of the magnetic aerohydrodynamic analogy
method to simulate three-dimensional flow past aircraft,
taking powerplant operation into account p 770 A86-48833
- ANALOG TO DIGITAL CONVERTERS**
- Multiple thermocouple testing device
[AD-D012276] p 850 N86-31860
- ANEMOMETERS**
- Anemobarometry: An essential element of flight
control p 835 N86-31566
- ANGLE OF ATTACK**
- Use of hinged strakes for lateral control at high angles
of attack p 830 A86-47696
[AIAA PAPER 86-2278]
- Vortex-induced effects on aircraft dynamics
p 830 A86-47697
[AIAA PAPER 86-2279]
- Angle-of-attack estimation for analysis of CAT
encounters p 831 A86-47798
- A study of the relationship between nonlinear changes
in the lifting force and the vortex structure of flow around
a low aspect ratio wing at large angles of attack
p 767 A86-48762
- Determination of the aerodynamic characteristics of
separated flow past a wing with allowance for slight
unsteadiness induced by changes in angle of attack
p 769 A86-48816
- Nonuniqueness of laminar separated flow around an
airfoil at angle of attack in the Kirchhoff scheme
p 769 A86-48822
- Experimental study of effects of forebody geometry on
high angle of attack static and dynamic stability and
control p 833 A86-49039
- Forebody vortex management for yaw control at high
angles of attack p 833 A86-49047
- Estimation of aerodynamic parameters from flight data
of a high incidence research model p 834 A86-49057
- High-angle-of-attack aerodynamics - Lessons learned
[AIAA PAPER 86-1774] p 777 A86-49578
- Flowfield survey over a 75 deg swept delta wing at an
angle of attack of 20.5 deg p 777 A86-49579
[AIAA PAPER 86-1775]
- Validation of a full potential method for combined yaw
and angle of attack p 779 A86-49591
[AIAA PAPER 86-1834]
- Preliminary results of unsteady blade surface pressure
measurements for the SR-3 propeller p 780 A86-49625
[AIAA PAPER 86-1893]
- Low-speed aerodynamic characteristics of a 1/8-scale
X-29A airplane model at high angles of attack and
sideslip p 781 N86-31532
[NASA-TM-87722]
- High speed viscous flow calculations about complex
configurations p 850 N86-31827
[NASA-TM-88237]
- Transonic Navier-Stokes wing solutions using a zonal
approach. Part 2: High angle-of-attack simulation
[NASA-TM-88248-PT-2] p 782 N86-32392
- A low speed tunnel semi-free dynamic flying study of
the high angle of attack pitch derivatives of HF-24 using
MLE procedure p 782 N86-32393
[NAL-TRM-SE-8603]
- ANGULAR VELOCITY**
- Quantifying a propeller/engine power response rate
mismatch p 796 A86-47801
- ANISOTROPIC MEDIA**
- Divergence of an anisotropic sweptforward wing
p 768 A86-48788
- ANISOTROPIC SHELLS**
- On the optimization of flutter characteristics of laminated
anisotropic cylindrical shells p 848 A86-49082
- ANTHROPOMETRY**
- Anthropometric conditions for the construction of a
helicopter cockpit p 794 A86-47768
- APPLICATIONS PROGRAMS (COMPUTERS)**
- ATRAN3S: An unsteady transonic code for clean
wings p 781 N86-31535
[NASA-TM-86783]
- NASA's Aircraft Icing Analysis Program
[NASA-TM-88791] p 786 N86-31548
- APPROACH**
- Test and flight evaluation of precision distance
measuring equipment p 788 A86-49017
- APPROACH CONTROL**
- Robust fault detection and isolation for a high
performance aircraft on STOL approach p 821 A86-47421
[AIAA PAPER 86-2031]
- Flight simulation of MLS interception procedures
applicable to laterally segmented approach paths
[AIAA PAPER 86-2073] p 837 A86-47663
- Determination of the statistical characteristics of aircraft
motion during an automatic approach p 832 A86-48844
- Investigations in landing process of aircraft by means
of the Monte-Carlo method p 808 N86-31578
[ESA-TT-951]
- APPROACH INDICATORS**
- Portable glide slope indicator
[AD-D012240] p 789 N86-31552
- Analysis of a mirror deck landing aid
[AD-A167988] p 789 N86-31556
- ARC GENERATORS**
- Design of a fast risetime lightning generator
p 837 A86-47304
- ARTIFICIAL INTELLIGENCE**
- An artificial intelligence approach to onboard fault
monitoring and diagnosis for aircraft applications
[AIAA PAPER 86-2083] p 853 A86-48577
- A knowledge-based expert system for scheduling of
airborne astronomical observations p 854 A86-49627
- ASPECT RATIO**
- The effect of the aspect ratio of the cylindrical section
on the fuselage drag at transonic flight velocities
p 768 A86-48801
- Aspect ratio effects on wings at low Reynolds
numbers p 782 N86-32390
- ASTRONOMICAL OBSERVATORIES**
- A knowledge-based expert system for scheduling of
airborne astronomical observations p 854 A86-49627
- ASYMPTOTIC PROPERTIES**
- A controller for robust asymptotic tracking in systems
with time-varying uncertainties p 853 A86-47479
[AIAA PAPER 86-2199]
- ATMOSPHERIC CHEMISTRY**
- Effect of the nonequilibrium character of the flow around
a blunt plate with a bend on its aerodynamic
characteristics p 768 A86-48783
- ATMOSPHERIC ELECTRICITY**
- Ring discharge on the backsurface of a composite skin
with ohmic anisotropy in response to frontal high current
injection p 845 A86-47329

- Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning p 804 A86-49132
- A wide bandwidth electrostatic field sensor for lightning research p 850 A86-50260
- ATMOSPHERIC TURBULENCE**
- Recent advances in Monte Carlo turbulence simulation --- for aircraft flight simulation p 792 A86-47636
- Calculation of the loading of the airframe in flight due to multidimensional turbulence p 799 A86-48759
- ATTACK AIRCRAFT**
- Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782
- ATTITUDE CONTROL**
- Lighter-than-air aircraft as control configured vehicle p 801 A86-48998
- Forebody vortex management for yaw control at high angles of attack p 833 A86-49047
- AUTOMATED EN ROUTE ATC**
- A simulation facility for assessing the next generation of 4-D air traffic control procedures p 788 A86-49034
- Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system [NPL-VG-84-009-L] p 789 N86-32419
- AUTOMATIC CONTROL**
- Rotary-wing aircraft terrain-following/terrain-avoidance system development [AIAA PAPER 86-2147] p 823 A86-47456
- Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760
- AUTOMATIC FLIGHT CONTROL**
- Simulation results of automatic restructurable flight control system concepts [AIAA PAPER 86-2032] p 821 A86-47422
- Synthesis of an adaptive flight controller under unknown deterministic disturbances [AIAA PAPER 86-2157] p 823 A86-47464
- An explicit adaptive flight control system based on the modified gain extended Kalman filter [AIAA PAPER 86-2158] p 823 A86-47465
- Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator [AIAA PAPER 86-2205] p 787 A86-47519
- Concept of automated aircraft guidance system for air-to-air missions [AIAA PAPER 86-2285] p 787 A86-47703
- Experts system control of autonomous airborne vehicle p 835 A86-49476
- AUTOMATIC LANDING CONTROL**
- Effects of time delay and pitch control sensitivity in the flared landing [AIAA PAPER 86-2075] p 831 A86-47706
- AUTOMATIC PILOTS**
- NASA B737 flight test results of the Total Energy Control System [AIAA PAPER 86-2143] p 826 A86-47516
- Strain-gauge autopilot altitude corrector p 811 A86-49142
- AUTOMATIC TEST EQUIPMENT**
- Potential of BITE's and what it means to aircraft maintenance p 759 A86-47607
- Working with today's BITE - One airline's experience p 759 A86-47608
- A minimum approach to flight testing p 810 A86-47780
- AUTONOMOUS NAVIGATION**
- Experts system control of autonomous airborne vehicle p 835 A86-49476
- AUTOROTATION**
- Optimal landing of a helicopter in autorotation [AIAA PAPER 86-2287] p 793 A86-47705
- AUXILIARY POWER SOURCES**
- Operation of the CT7 turboprop engine as an auxiliary power unit (APU) [ASME PAPER 86-GT-28] p 812 A86-48119
- The GTCP36-300 - A gas turbine auxiliary power unit for advanced technology transport aircraft [ASME PAPER 86-GT-285] p 816 A86-48302
- Digital engine control units for an fighter engine and an auxiliary power unit - A comparison p 817 A86-49089
- AVIONICS**
- Special protection circuits against transient currents for aircraft systems p 791 A86-47326
- Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors [AIAA PAPER 86-2030] p 810 A86-47511
- AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Duesseldorf, West Germany, February 26-March 3, 1985, Conference Reports p 759 A86-47601

- Potential of BITE's and what it means to aircraft maintenance p 759 A86-47607
- Working with today's BITE - One airline's experience p 759 A86-47608
- Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 760 A86-47609
- Avionics digital data acquisition system p 810 A86-47790
- The development of a fibre optic data bus for helicopters p 811 A86-49131
- AXIAL FLOW TURBINES**
- Predictions of endwall losses and secondary flows in axial flow turbine cascades [ASME PAPER 86-GT-228] p 766 A86-48262

B

- BALLISTICS**
- The drag of a pair of bodies at supersonic flight velocities p 768 A86-48802
- BAROMETERS**
- Anemobarometry: An essential element of flight control p 835 N86-31566
- BENDING**
- Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003
- BENDING VIBRATION**
- The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918
- BIODYNAMICS**
- Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495
- BIRD-AIRCRAFT COLLISIONS**
- Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055
- BLADE SLAP NOISE**
- Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller [AIAA PAPER 86-1893] p 780 A86-49625
- Noise control characteristics of synchrophasing. II - Experimental investigation --- on aircraft fuselage model p 805 A86-49808
- BLADE TIPS**
- Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580
- BLOWING**
- Aerodynamics of delta wings with leading edge blowing [AIAA PAPER 86-2230] p 764 A86-47691
- Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack [AIAA PAPER 86-2277] p 830 A86-47695
- BLUNT BODIES**
- Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783
- BO-105 HELICOPTER**
- Development of the BO 105 LS [MBB-UD-456-85-OE] p 805 A86-50255
- BODY-WING AND TAIL CONFIGURATIONS**
- An experimental study of a three lifting surface configuration p 775 A86-49104
- BODY-WING CONFIGURATIONS**
- Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
- Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838
- Optimum-Optimorum integrated wing-fuselage configuration for supersonic transport aircraft of second generation p 801 A86-49010
- Algebraic grid generation about wing-fuselage bodies p 772 A86-49028
- Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046
- PN/S calculations for a fighter W/F at high-lift yaw conditions --- parabolized Navier-Stokes computer code [AIAA PAPER 86-1829] p 779 A86-49588
- Navier-Stokes simulation of transonic flow over wing-fuselage combinations [AIAA PAPER 86-1831] p 779 A86-49589
- Elliptic generation of composite three-dimensional grids about realistic aircraft [NASA-TM-88240] p 763 N86-31527
- BOEING 747 AIRCRAFT**
- 747 modernization p 800 A86-48985
- BOEING 757 AIRCRAFT**
- Precise control surface position measurements for hysteresis and twist testing p 795 A86-47789

BONDING

- Low mass diffusion bonding tools [AD-D012295] p 851 N86-32746
- BOOLEAN FUNCTIONS**
- Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760
- BOUNDARY LAYER CONTROL**
- Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing [AAAF PAPER NT 85-03] p 766 A86-48454
- BOUNDARY LAYER EQUATIONS**
- Predictions of endwall losses and secondary flows in axial flow turbine cascades [ASME PAPER 86-GT-228] p 766 A86-48262
- Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031
- BOUNDARY LAYER FLOW**
- Calculation of flow over multielement airfoils at high lift p 772 A86-49011
- An experimental study of turbulent wake/boundary layer mixing flows p 772 A86-49014
- Wake/boundary-layer interactions in two and three dimensions p 773 A86-49032
- BOUNDARY LAYER SEPARATION**
- Acoustic effect on stall hysteresis for low Reynolds number laminar flow p 855 A86-47971
- Theoretical and experimental analysis of separations on helicopter fuselages [AAAF PAPER NT 85-08] p 766 A86-48458
- A new, improved method for separating turbulent boundary layer for aerodynamic performance prediction of trailing edge stall airfoils [AIAA PAPER 86-1832] p 779 A86-49590
- Sounding a happy note for lift --- sound generation to prevent stalling p 780 A86-49676
- BOUNDARY LAYER TRANSITION**
- Boundary-layer transition effects on airplane stability and control [AIAA PAPER 86-2229] p 831 A86-47708
- Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing [AAAF PAPER NT 85-03] p 766 A86-48454
- Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions [AAAF PAPER NT 85-06] p 838 A86-48457
- BOUNDARY LAYERS**
- Interior transition layers in flight path optimization [AIAA PAPER 86-2037] p 797 A86-48576
- BOXES (CONTAINERS)**
- Manufacturing technology of composite torque box of vertical fin p 848 A86-49068
- BRAKES (FOR ARRESTING MOTION)**
- Fireproof hydraulic brake system [AD-A167774] p 786 N86-31549
- BRAKING**
- A certain type of self-oscillation of aircraft landing-gear wheels p 800 A86-48829
- BREATHING APPARATUS**
- Scott emergency escape breathing device - Evaluation for use in Canadian forces aircraft p 784 A86-47731
- Development of a new lightweight emergency escape breathing device p 784 A86-47760
- BUCKLING**
- The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001
- BURGER EQUATION**
- Truncated Taylor series solutions to a generalized Burgers' equation p 856 A86-49716
- BYPASSES**
- Flight testing of general electric high bypass engines evolution and revolution p 812 A86-47786
- C**
- C-135 AIRCRAFT**
- Re-engine KC-135R/CFM56 flight test program - An overview p 795 A86-47793
- Fireproof hydraulic brake system [AD-A167774] p 786 N86-31549
- C-141 AIRCRAFT**
- A knowledge-based expert system for scheduling of airborne astronomical observations p 854 A86-49627
- CALIBRATING**
- The F2 wind tunnel of the Fauga-Mauzac Test Center [ONERA, TP NO. 1986-104] p 839 A86-49075
- Simulator scene display evaluation device [NASA-CASE-ARC-11504-1] p 840 N86-32447
- CAMBERED WINGS**
- Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563

CANARD CONFIGURATIONS

- The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056
- Aeroelastic tailoring for flutter constraints p 802 A86-49081
- Canard canard --- performance of light aircraft p 783 A86-49682

CANOPIES

- Concept development of a canopy escape module p 784 A86-47759

CANTILEVER MEMBERS

- Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan [ASME PAPER 86-GT-98] p 813 A86-48163
- Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779

CARBON DIOXIDE

- Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels [ASME PAPER 86-GT-163] p 843 A86-48216

CARBON FIBER REINFORCED PLASTICS

- Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331
- A round-up on CFRP p 841 A86-47602
- Analysis of the costs and weight effects of CFK on air transport structure p 842 A86-48097
- Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure p 785 A86-48989
- The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001

CASCADE FLOW

- Some aspects of supersonic flow over a cavity cascade [AIAA PAPER 86-2025] p 764 A86-47659
- Development of an experimental correlation for transonic turbine flow [ASME PAPER 86-GT-108] p 765 A86-48170
- Numerical solution of transonic stream function equation on S1 stream surface in cascade [ASME PAPER 86-GT-110] p 765 A86-48172
- Evaluation of the blade-to-blade flow from a high speed compressor rotor [ASME PAPER 86-GT-117] p 765 A86-48176
- A method for transonic inverse cascade design with a stream function equation [ASME PAPER 86-GT-189] p 766 A86-48239
- Predictions of endwall losses and secondary flows in axial flow turbine cascades [ASME PAPER 86-GT-228] p 766 A86-48262
- Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller [AIAA PAPER 86-1893] p 780 A86-49625

CASCADE WIND TUNNELS

- Aerodynamic design methods for modern transport aircraft [ESA-TT-923] p 782 N86-31543

CASE HISTORIES

- Case studies in aircraft manufacturing automation p 762 A86-49000

CATAPULTS

- Development of a controllable catapult for ejection seats p 793 A86-47733
- Catapult holdback design examined p 838 A86-48041

CAVITATION FLOW

- Some aspects of supersonic flow over a cavity cascade [AIAA PAPER 86-2025] p 764 A86-47659

CENTRIFUGAL FORCE

- Optimum design technique for rotating wheels [ASME PAPER 86-GT-255] p 846 A86-48281

CERAMICS

- Fabrication of high-alumina ceramic fixtures for jet engine repair applications [ASME PAPER 86-GT-46] p 846 A86-48130

CERTIFICATION

- Advanced icing wind tunnel for flight test development of icing rate systems p 838 A86-47792
- Certification of advanced experimental aircraft p 785 A86-49036
- A contribution to airworthiness certification of gas turbine disks p 849 A86-49136
- Dynamic identification procedure and lift certification of light aircraft and gliders [ONERA-RT-12/1677-RY-090-R] p 809 N86-32429
- CESSNA 172 AIRCRAFT**
- Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042
- CHANNELS (DATA TRANSMISSION)**
- The development of a fibre optic data bus for helicopters p 811 A86-49131

CHEMICAL ANALYSIS

- Analytical applications in the Army oil analysis program p 845 A86-47595
- Chemical analysis for control --- of Al alloy aircraft structures p 842 A86-47720

CHEMICAL FUELS

- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants [AD-A167444] p 807 N86-31572

CHINA

- Aircraft maintenance in China - Approaches to modernization p 760 A86-47615

CHINESE AIRCRAFT

- The helicopter technology of China p 761 A86-48652

CINEMATOGRAPHY

- Interferometric holographic cinematography [ISL-CO-219/85] p 851 N86-31872

CIRCUIT PROTECTION

- Special protection circuits against transient currents for aircraft systems p 791 A86-47326

CIRCULATION CONTROL AIRFOILS

- Similarity criteria for a circulation control airfoil p 769 A86-48815

CIVIL AVIATION

- Civil helicopter handling qualities requirements for visual and instrument flight p 832 A86-48674
- Active control technology for civil transport p 832 A86-49005
- Designing a load alleviation system for a modern civil aircraft p 832 A86-49006
- Managing airworthiness p 785 A86-49035

CLEAR AIR TURBULENCE

- Angle-of-attack estimation for analysis of CAT encounters p 831 A86-47798

CLIMBING FLIGHT

- The INS wind calibration in climb algorithm p 796 A86-47799

CLOUD GLACIATION

- Field observations of aircraft charging in convective clouds p 783 A86-47332

COANDA EFFECT

- Similarity criteria for a circulation control airfoil p 769 A86-48815

COCKPITS

- Anthropometric conditions for the construction of a helicopter cockpit p 794 A86-47768
- The British Aerospace Experimental Aircraft Programme and the role of system development cockpits p 801 A86-48996

COLLISION AVOIDANCE

- The risk of collision in a two seat aircraft ejection p 783 A86-47730
- Performance evaluation of a linear recursive technique for aircraft altitude prediction in airborne collision avoidance systems p 811 A86-49085
- Air safety: Federal Aviation Administration's role in developing mid-air collision avoidance back-up systems [PB86-197506] p 787 N86-32418

COMBAT

- Concept of automated aircraft guidance system for air-to-air missions [AIAA PAPER 86-2285] p 787 A86-47703
- Survivability considerations during aircraft conceptual design [AD-A168555] p 809 N86-32428

COMBINED STRESS

- Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading p 848 A86-49040

COMBUSTION CHAMBERS

- The performance of a reverse flow combustor using JP 10 fuel [ASME PAPER 86-GT-146] p 814 A86-48202
- Conical grid plate flame stabilizers - Stability and emissions for liquid fuels [ASME PAPER 86-GT-156] p 842 A86-48210
- Premixing gas and air to reduce NO_x emissions with existing proven gas turbine combustion chambers [ASME PAPER 86-GT-157] p 814 A86-48211
- A study on NO_x emissions from gas turbine combustor [ASME PAPER 86-GT-168] p 814 A86-48220
- Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads [ASME PAPER 86-GT-172] p 815 A86-48224
- Fuel effects on aircraft combustor emissions [ASME PAPER 86-GT-212] p 815 A86-48252
- Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation [AIAA PAPER 86-1452] p 818 A86-49611

- Perspectives on dilution jet mixing --- in creating temperature patterns at combustor exits in gas turbine engines [AIAA PAPER 86-1611] p 818 A86-49614

- Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation [NASA-TM-87304] p 819 N86-31582

COMBUSTION EFFICIENCY

- Regression rate study for a solid fuel ramjet p 818 A86-49113

- Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation [NASA-TM-87304] p 819 N86-31582

COMBUSTION PHYSICS

- Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels [ASME PAPER 86-GT-163] p 843 A86-48216

COMMERCIAL AIRCRAFT

- Thirty years with the jets: Commercial transport flight management systems - Past, present, and future [AIAA PAPER 86-2289] p 821 A86-47402
- Pilot evaluation of experimental flight trajectories in the near-terminal area [AIAA PAPER 86-2074] p 838 A86-47664
- Analysis of the costs and weight effects of CFK on air transport structure p 842 A86-48097
- Reduction of turbulent drag - Turbulence manipulators [AAAF PAPER NT 85-04] p 766 A86-48455
- Avionics fault data acquisition - A concept for civil transport aircraft p 810 A86-49051
- A propfan status report p 817 A86-49091
- Propfan and turbofan - Antagonism or synthesis p 817 A86-49092
- Potential application of advanced propulsion systems to civil aircraft p 802 A86-49093
- Aeroelastic tailoring of aft-swept high aspect ratio composite wings p 802 A86-49097
- On the computation of wing lift interference caused by high bypass engines p 776 A86-49109

COMPENSATORY TRACKING

- Cooperative synthesis of control and display augmentation [AIAA PAPER 86-2204] p 853 A86-47484

COMPOSITE MATERIALS

- Multipath lightning protection for composite structure integral fuel tank design p 790 A86-47308
- Composites in today's and tomorrow's U.S. airliners p 841 A86-47803
- How one A/C manufacturer transits to composites p 759 A86-47604
- Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830
- Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials p 762 A86-49067
- Manufacturing technology of composite torque box of vertical fin p 848 A86-49068
- Manufacturers seek reduced costs through new fabrication techniques p 762 A86-49448

COMPOSITE STRUCTURES

- Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection p 845 A86-47329
- How one A/C manufacturer transits to composites p 759 A86-47604
- Aeroelastic behavior of low aspect ratio metal and composite blades [ASME PAPER 86-GT-243] p 846 A86-48271
- Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
- Fibre optic damage detection in composite structures p 848 A86-48988
- Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003
- Plastic or metal - The judgement factors --- for selecting aircraft construction material p 762 A86-49037
- A general formulation for the aeroelastic divergence of composite sweptforward wing structures p 802 A86-49095
- Aeroelastic tailoring of aft-swept high aspect ratio composite wings p 802 A86-49097
- Optimization of composite structures by controlled insertion or deletion of diverse fiber types p 844 A86-50122
- Structural design and analysis aspects of composite helicopter components [MBB-UD-454-85-OE] p 806 A86-50256
- Weight estimation techniques for composite airplanes in general aviation industry [NASA-CR-178163] p 781 N86-31531

COMPRESSIBLE FLOW

- An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow
[AIAA PAPER 86-0467] p 856 A86-49566
- Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258

COMPRESSION LOADS

- Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading p 848 A86-49040

COMPRESSOR BLADES

- Splitter blades as an aeroelastic detuning mechanism for unstalled supersonic flutter of turbomachine rotors [ASME PAPER 86-GT-99] p 813 A86-48184
- Evaluation of the blade-to-blade flow from a high speed compressor rotor [ASME PAPER 86-GT-117] p 765 A86-48176
- Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064

COMPRESSOR ROTORS

- Evaluation of the blade-to-blade flow from a high speed compressor rotor [ASME PAPER 86-GT-117] p 765 A86-48176
- Optimum design technique for rotating wheels [ASME PAPER 86-GT-255] p 846 A86-48281
- TURBISTAN: A standard load sequence for aircraft engine disks [NLR-MP-85033-U] p 820 N86-32436
- Cost reductions from introduction of new life philosophies for aircraft engine discs [NLR-MP-85076-U] p 820 N86-32438

COMPRESSORS

- Subsonic/transonic stall flutter investigation of an advanced low pressure compressor [ASME PAPER 86-GT-90] p 813 A86-48156

COMPUTATIONAL FLUID DYNAMICS

- Parametric study of low Reynolds number precessing/spinning incompressible flows --- applicable to flight stability of liquid-filled projectiles [AIAA PAPER 86-2027] p 827 A86-47661
- Numerical solution of transonic stream function equation on S1 stream surface in cascade [ASME PAPER 86-GT-110] p 765 A86-48172
- A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method [ASME PAPER 86-GT-111] p 765 A86-48173
- CFD for engine-airframe integration [ASME PAPER 86-GT-125] p 797 A86-48184
- Particulate flow solutions through centrifugal impeller with two splitters [ASME PAPER 86-GT-130] p 765 A86-48188
- A method for transonic inverse cascade design with a stream function equation [ASME PAPER 86-GT-189] p 766 A86-48239
- Blending method for grid generation --- for computational fluid dynamics p 766 A86-48428
- Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results --- German thesis p 767 A86-48568
- A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers p 847 A86-48647
- Overview of helicopter wake and airloads technology p 767 A86-48654
- Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807
- Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809
- Efficient solution of three-dimensional Euler equations using embedded grids p 771 A86-49007
- Transonic computations about complex configurations using coupled inner and outer flow equations p 771 A86-49008
- Application of the TranAir full-potential code to complete configurations p 772 A86-49009
- Calculation of flow over multielement airfoils at high lift p 772 A86-49011
- Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027
- Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031
- Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045
- Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049
- Analysis of the vortical flow around a 60 degree delta wing with vortex flap p 774 A86-49050
- Advances at AEDC in treating transonic wind tunnel wall interference p 839 A86-49058

- Numerical design parameter study for slotted walls in transonic wind tunnels p 839 A86-49059
- Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method p 839 A86-49060
- The F2 wind tunnel of the Fauge-Mauzac Test Center [ONERA, TP NO. 1986-104] p 839 A86-49075
- The role of flow field computation in improving turbomachinery p 775 A86-49080
- Applications of potential theory computations to transonic aeroelasticity p 775 A86-49105
- Utilization of computation and experiment for airframe propulsion integration development p 803 A86-49110
- An entropy correction method for unsteady full potential flows with strong shocks [AIAA PAPER 86-1768] p 777 A86-49576
- Three-dimensional transonic flow computations on simple skewed grids [AIAA PAPER 86-1794] p 778 A86-49581
- Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches [AIAA PAPER 86-1821] p 778 A86-49586
- PN/S calculations for a fighter W/F at high-lift yaw conditions --- parabolized Navier-Stokes computer code [AIAA PAPER 86-1829] p 779 A86-49588
- Navier-Stokes simulation of transonic flow over wing-fuselage combinations [AIAA PAPER 86-1831] p 779 A86-49589
- Validation of a full potential method for combined yaw and angle of attack [AIAA PAPER 86-1834] p 779 A86-49591
- Trapping of a free vortex by airfoils with surface suction p 780 A86-49801
- Recent developments in rotary-wing aerodynamic theory p 780 A86-49802
- Airfoil trailing-edge flow measurements p 780 A86-49803
- Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- Computation of the potential flow over airfoils with cusped or thin trailing edges p 780 A86-49823
- Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258
- ATRAN3S: An unsteady transonic code for clean wings [NASA-TM-86783] p 781 N86-31535
- Computations of separated subsonic and transonic flow about airfoils in unsteady motion [NLR-MP-84094-U] p 782 N86-31541
- High speed viscous flow calculations about complex configurations [NASA-TM-88237] p 850 N86-31827
- Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392

COMPUTATIONAL GRIDS

- Blending method for grid generation --- for computational fluid dynamics p 766 A86-48428
- Efficient solution of three-dimensional Euler equations using embedded grids p 771 A86-49007
- Transonic computations about complex configurations using coupled inner and outer flow equations p 771 A86-49008
- Application of the TranAir full-potential code to complete configurations p 772 A86-49009
- Algebraic grid generation about wing-fuselage bodies p 772 A86-49028
- Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model p 776 A86-49245
- Three-dimensional transonic flow computations on simple skewed grids [AIAA PAPER 86-1794] p 778 A86-49581
- Elliptic generation of composite three-dimensional grids about realistic aircraft [NASA-TM-88240] p 763 N86-31527
- High speed viscous flow calculations about complex configurations [NASA-TM-88237] p 850 N86-31827

COMPUTER AIDED DESIGN

- Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659
- Applications of computer-aided engineering to subsonic aircraft design in a university environment p 801 A86-48986
- Automated structural optimisation at Warton --- for aircraft p 854 A86-48987
- Advances in turbine technology p 817 A86-49079
- Design bureaux: The brain drainers. I - Toulouse - Aircraft mobilize a task force over 1700-strong p 763 A86-49464
- The development of aeroelastic tailoring in the United States p 805 A86-50111

- Aerodynamic design methods for modern transport aircraft [ESA-TT-923] p 782 N86-31543
- Simulation and optimization techniques in computer aided design [NLR-MP-85022-U] p 854 N86-33053
- An infrastructure for information processing for computer aided design [NLR-MP-85038-U] p 854 N86-33054

COMPUTER AIDED MANUFACTURING

- Manufacturers seek reduced costs through new fabrication techniques p 762 A86-49448

COMPUTER GRAPHICS

- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AIAA-167717] p 781 N86-31539
- A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations [ESA-TT-928] p 789 N86-31558

COMPUTER PROGRAMMING

- KRASH 85 user's guide: Input/output format, revision [AD-A168846] p 787 N86-32416

COMPUTER PROGRAMS

- Aspect ratio effects on wings at low Reynolds numbers p 782 N86-32390
- Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042

COMPUTER TECHNIQUES

- Determination of the required number of channels for controlling aircraft wing loading for several cases of calculation p 768 A86-48787
- Application of strain gauge amplifiers and computer technology to the strength testing of aircraft p 849 A86-49144

COMPUTERIZED SIMULATION

- Induced current surface density after a direct lightning strike on an aircraft p 790 A86-47297
- MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation --- for F-14 flight simulation [AIAA PAPER 86-2085] p 853 A86-47505
- Computational engine structural analysis [ASME PAPER 86-GT-70] p 813 A86-48141
- An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 763 N86-31529
- NASA's Aircraft Icing Analysis Program [NASA-TM-88791] p 786 N86-31548
- Development of a takeoff performance monitoring system [NASA-TM-89001] p 835 N86-31591
- KRASH 85 user's guide: Input/output format, revision [AD-A168846] p 787 N86-32416
- Simulation and optimization techniques in computer aided design [NLR-MP-85022-U] p 854 N86-33053

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CONSTITUTIVE EQUATIONS

- Unified constitutive materials model development and evaluation for high-temperature structural analysis applications --- for aircraft gas turbine engines p 849 A86-49133

CONSTRUCTION

- The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001

CONTROL CONFIGURED VEHICLES

- Simulation results of automatic restructurable flight control system concepts [AIAA PAPER 86-2032] p 821 A86-47422

Control reconfigurable combat aircraft flight control system development
[AIAA PAPER 86-2236] p 824 A86-47488
Lighter-than-air aircraft as control configured vehicle
p 801 A86-48998

CONTROL EQUIPMENT
Aircraft control surface failure detection and isolation using the OSGLR test — orthogonal series generalized likelihood ratio
[AIAA PAPER 86-2028] p 821 A86-47419

CONTROL SIMULATION
Simulation results of automatic restructurable flight control system concepts
[AIAA PAPER 86-2032] p 821 A86-47422
Turbulence response matching in the NT-33A in-flight simulator
[AIAA PAPER 86-2076] p 827 A86-47665
On control concept for in-flight simulation including actuator nonlinearities and time delays
[ESA-TT-948] p 836 N86-31593
An approach to integrated aeroservoelastic tailoring for stability
p 836 N86-32439

CONTROL STABILITY
A design methodology for robust stabilizing controllers
[AIAA PAPER 86-2195] p 823 A86-47475
Servo-actuator for sampled-data feedback disturbance rejection — helicopters
[DFVLR-FB-86-08] p 837 N86-32446

CONTROL SURFACES
Aircraft control surface failure detection and isolation using the OSGLR test — orthogonal series generalized likelihood ratio
[AIAA PAPER 86-2028] p 821 A86-47419
Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft
p 794 A86-47782
Precise control surface position measurements for hysteresis and twist testing
p 795 A86-47789
Dynamic response of the A.310 in flight to control-surface loading
[AAAF PAPER NT 85-18] p 797 A86-48467
Influence of EFCS-control laws on structural design of modern transport aircraft
p 800 A86-48984

CONTROL SYSTEMS DESIGN
Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers
p 852 A86-47401
A stochastic decentralized flight control system
[AIAA PAPER 86-1994] p 821 A86-47416
Single-state observer design considerations for aircraft application
[AIAA PAPER 86-1996] p 852 A86-47418
Simulation results of automatic restructurable flight control system concepts
[AIAA PAPER 86-2032] p 821 A86-47422
Evaluation of total energy-rate feedback for glidescope tracking in wind shear
[AIAA PAPER 86-2035] p 822 A86-47424
RT-BUILD - Automatic generation of Ada code for flight control applications
[AIAA PAPER 86-2088] p 852 A86-47439
A theory for fault-tolerant flight control combining expert system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442
Synthesis of an adaptive flight controller under unknown deterministic disturbances
[AIAA PAPER 86-2157] p 823 A86-47464
A design methodology for robust stabilizing controllers
[AIAA PAPER 86-2195] p 823 A86-47475
Automated pole placement algorithm for multivariable optimal control synthesis
[AIAA PAPER 86-2196] p 852 A86-47476
A preliminary investigation of H (infinity) optimization
[AIAA PAPER 86-2197] p 853 A86-47477
Limitations of statically unstable aircraft due to the effects of sensor noise, turbulence, and structural dynamics
[AIAA PAPER 86-2203] p 824 A86-47483
Control reconfigurable combat aircraft flight control system development
[AIAA PAPER 86-2236] p 824 A86-47488
Flight control system development and flight test experience with the F-111 mission adaptive wing aircraft
[AIAA PAPER 86-2237] p 824 A86-47489
Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model
[AIAA PAPER 86-2242] p 824 A86-47490
Application of eigenstructure assignment to design of robust decoupling controllers in MIMO systems — for helicopters
[AIAA PAPER 86-2246] p 825 A86-47493
Design of a multivariable flutter control/gust load alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494

A fundamental approach to equivalent systems analysis — in evaluating aircraft handling qualities
[AIAA PAPER 86-2128] p 828 A86-47674
Development of a controllable catapult for ejection seats
p 793 A86-47733
Flight test experience and controlled impact of a large, four-engine remotely piloted airplane
p 794 A86-47781
Airbus A 320 - New concept of aircraft control
p 796 A86-47797
Development of HIDECA adaptive engine control systems
[ASME PAPER 86-GT-252] p 816 A86-48278
Active flutter suppression
p 832 A86-49004
Design criteria for flight control systems
p 833 A86-49023
Digital engine control units for an fighter engine and an auxiliary power unit - A comparison
p 817 A86-49089
Integrated structure/control design - Present methodology and future opportunities
p 854 A86-49094
Design of a nonlinear lever-type mechanism for aircraft control systems
p 835 A86-49139
Failure detection in a flight control system by the modified sequential probability ratio test
p 854 A86-49507
Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2
[NASA-CR-4014] p 836 N86-32440

CONTROL THEORY
A preliminary investigation of H (infinity) optimization
[AIAA PAPER 86-2197] p 853 A86-47477
A controller for robust asymptotic tracking in systems with time-varying uncertainties
[AIAA PAPER 86-2199] p 853 A86-47479
Case studies of the effects on non-linearities on the accuracy of gas turbine control
p 817 A86-49090

CONTROLLERS
A controller for robust asymptotic tracking in systems with time-varying uncertainties
[AIAA PAPER 86-2199] p 853 A86-47479

CONVECTION CLOUDS
Field observations of aircraft charging in convective clouds
p 783 A86-47332

COOLING
Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation
[AIAA PAPER 86-1452] p 818 A86-49611
Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation
[NASA-TM-87304] p 819 N86-31582

CORROSION PREVENTION
Early corrosion detection and prevention measures — for aircraft
p 760 A86-47612
Coatings — for Al alloy corrosion control
p 845 A86-47721

CORROSION RESISTANCE
Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577

COST ANALYSIS
Analysis of the costs and weight effects of CFK on air transport structure
p 842 A86-48097

COST REDUCTION
The British Aerospace Experimental Aircraft Programme and the role of system development cockpits
p 801 A86-48996
Manufacturers seek reduced costs through new fabrication techniques
p 762 A86-49448
An overview of the Small Engine Component Technology (SECT) studies
[NASA-TM-88796] p 819 N86-31587

COUPLED MODES
Self-oscillatory regimes of aircraft motion during spin-roll coupling
p 832 A86-48775

CRACK PROPAGATION
Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners)
[SNIA-436.021/85] p 851 N86-32784

CRACKS
Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing
p 845 A86-47613
The effect of a fault on the stiffness and the natural frequency of a plate in bending
p 850 A86-49918

CRASH LANDING
Advancements in inertia reels for fixed seating aircraft
p 784 A86-47744
Emergency underwater escape from helicopters
p 784 A86-47745
Structural dynamics research in a full-scale transport aircraft crash test
p 785 A86-49053

Experimental investigation of electrostatic fire and explosion accidents after aircraft landing and preventive design
p 786 A86-49083

CRASHES
KRASH 85 user's guide: Input/output format, revision
[AD-A168846] p 787 N86-32416

CRASHWORTHINESS
Flight test experience and controlled impact of a large, four-engine remotely piloted airplane
p 794 A86-47781
Computing codes for development of helicopter crashworthy structures and test substantiation
p 798 A86-48657

CROSS FLOW
Perspectives on dilution jet mixing — in creating temperature patterns at combustor exits in gas turbine engines
[AIAA PAPER 86-1611] p 818 A86-49614

CRUISING FLIGHT
A study of aircraft cruise
[AIAA PAPER 86-2286] p 792 A86-47704
Reducing fuel consumption by cyclic control
p 832 A86-48991

CRUSHING
Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure
p 848 A86-49003

CRYOGENIC WIND TUNNELS
Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457

CUMULATIVE DAMAGE
Cost reductions from introduction of new life philosophies for aircraft engine discs
[NLR-MP-85076-U] p 820 N86-32438

CURRENT DENSITY
Induced current surface density after a direct lightning strike on an aircraft
p 790 A86-47297

CUSPS
Computation of the potential flow over airfoils with cusped or thin trailing edges
p 780 A86-49823

CYLINDRICAL BODIES
Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660
The effect of the aspect ratio of the cylindrical section on the fuselage drag at transonic flight velocities
p 768 A86-48801
Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack
p 770 A86-48825
Intersection of an oblique shock wave with a cylindrical afterbody
p 775 A86-49098

CYLINDRICAL SHELLS
On the optimization of flutter characteristics of laminated anisotropic cylindrical shells
p 848 A86-49082
Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load
p 849 A86-49128

D

DAMAGE
Durability and damage tolerance assessment of the TF34-100 engine
[ASME PAPER 86-GT-38] p 812 A86-48125
Evaluation of damage tolerance requirements using a probabilistic-based life approach
[ASME PAPER 86-GT-266] p 847 A86-48288

DAMAGE ASSESSMENT
Supplemental inspections of aging aircraft
p 845 A86-47525
Fibre optic damage detection in composite structures
p 848 A86-48988

DATA ACQUISITION
A minimum approach to flight testing
p 810 A86-47780
Avionics digital data acquisition system
p 810 A86-47790
From mainframe to micro - Structures and flutter testing at the Air Force Flight Test Center
p 838 A86-47791
Optimization of onboard systems of data acquisition and processing — Russian book
p 810 A86-48531
Flight path reconstruction - A powerful tool for data compatibility check
p 833 A86-49041
Avionics fault data acquisition - A concept for civil transport aircraft
p 810 A86-49051
Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations
[AD-A167717] p 781 N86-31539

DATA BASE MANAGEMENT SYSTEMS

- An infrastructure for information processing for computer aided design
[NLR-MP-85038-U] p 854 N86-33054
- DATA BASES**
Method of analysing data on a swept wing aircraft in flight p 775 A86-49103
- DATA SAMPLING**
Servo-actuator for sampled-data feedback disturbance rejection — helicopters
[DFVLR-FB-86-08] p 837 N86-32446
- DATA SYSTEMS**
Engine condition monitoring at KLM Royal Dutch Airlines
[ASME PAPER 86-GT-300] p 816 A86-48312
- DECOUPLING**
Application of eigenstructure assignment to design of robust decoupling controllers in MIMO systems — for helicopters
[AIAA PAPER 86-2246] p 825 A86-47493
Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 N86-31568
- DEFECTS**
Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003
- DEICERS**
NASA's aircraft icing analysis program p 786 A86-49107
NASA's Aircraft Icing Analysis Program
[NASA-TM-88791] p 786 N86-31548
- DELTA WINGS**
Aerodynamics of delta wings with leading edge blowing
[AIAA PAPER 86-2230] p 764 A86-47691
Determination of the aerodynamic characteristics of separated flow past a wing with allowance for slight unsteadiness induced by changes in angle of attack p 769 A86-48816
Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838
A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842
Optimum-Optimorum integrated wing-fuselage configuration for supersonic transport aircraft of second generation p 801 A86-49010
Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027
Leading edge vortex flow over a 75 degree-swept delta wing: Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045
Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046
Analysis of the vortical flow around a 60 degree delta wing with vortex flap p 774 A86-49050
The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174
Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg p 777 A86-49579
[AIAA PAPER 86-1775] p 777 A86-49579
Low-speed aerodynamics of apex fences on a tailless delta configuration p 779 A86-49593
[AIAA PAPER 86-1838] p 779 A86-49593
Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258
- DESCENT TRAJECTORIES**
Design factors and considerations for a time-based flight management system
[AIAA PAPER 86-2144] p 822 A86-47455
- DESIGN ANALYSIS**
Multipath lightning protection for composite structure integral fuel tank design p 790 A86-47308
Sensor selection for the Boeing CREST ejection seat design p 793 A86-47757
Life cycle cost methodology for preliminary design evaluation
[ASME PAPER 86-GT-37] p 812 A86-48124
Dynamic aspects in the design of advanced rotor systems p 798 A86-48663
Application of a full potential method to practical problems in supersonic aircraft design and analysis p 773 A86-49030
The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques — aircraft design
[NLR-TR-85014-U] p 809 N86-32430

DETECTORS

- Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507
- DICARBOXYLIC ACIDS**
The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963
- DIFFUSION WELDING**
Low mass diffusion bonding tools
[AD-D012295] p 851 N86-32746
- DIGITAL COMMAND SYSTEMS**
Development of HIDECA adaptive engine control systems
[ASME PAPER 86-GT-252] p 816 A86-48278
- DIGITAL COMPUTERS**
Implications associated with the operation of digital data processing in the presence of the relatively harsh EMP environments produced by lightning p 809 A86-47319
Multiple thermocouple testing device
[AD-D012276] p 850 N86-31860
- DIGITAL SIMULATION**
Flight simulation techniques with emphasis on the generation of high fidelity 6 DOF motion cues p 839 A86-49024
- DIGITAL SYSTEMS**
Sensitivity analysis of high-order digital flight control systems using singular-value concepts
[AIAA PAPER 86-2084] p 822 A86-47437
Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 760 A86-47609
Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control
[AIAA PAPER 86-2017] p 826 A86-47652
Flight testing on customer aircraft with a portable airborne digital data system p 810 A86-47788
Avionics digital data acquisition system p 810 A86-47790
The M53 turbofan control system - A strong basis for the development of the future digital control systems p 817 A86-49088
Digital engine control units for an fighter engine and an auxiliary power unit - A comparison p 817 A86-49089
- DIRECT LIFT CONTROLS**
Design of a vertical thrust stand for a remotely piloted model helicopter
[AD-A167811] p 840 N86-31598
- DISPERSION**
Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels
[NASA-TM-87316] p 820 N86-31588
- DISPLAY DEVICES**
Cooperative synthesis of control and display augmentation
[AIAA PAPER 86-2204] p 853 A86-47484
Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779] p 789 N86-31551
Multiple thermocouple testing device
[AD-D012276] p 850 N86-31860
Simulator scene display evaluation device
[NASA-CASE-ARC-11504-1] p 840 N86-32447
An improved optical viewing system for a flight simulator
[MS-8025] p 840 N86-32448
- DISSOLVED GASES**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573
- DISTANCE MEASURING EQUIPMENT**
Test and flight evaluation of precision distance measuring equipment p 788 A86-49017
- DISTRIBUTED PROCESSING**
Smart probes for air data p 811 A86-49498
- DITCHING (LANDING)**
Emergency underwater escape from helicopters p 784 A86-47745
A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054
- DIVERGENCE**
Divergence of an anisotropic sweptforward wing p 768 A86-48788
- DO-28 AIRCRAFT**
Identification of gust input and gust response characteristics from Do 28 TNT flight test data
[ESA-TT-919] p 837 N86-32445
- DORNIER AIRCRAFT**
Results of technology programs for general aviation aircraft at Dornier p 795 A86-47787
- DRAG COEFFICIENTS**
Wave drag of a supersonic air intake at high subsonic velocities p 770 A86-48834

- Transonic wave drag estimation and optimization using the nonlinear area rule
[AIAA PAPER 86-1798] p 778 A86-49582
- DRAG REDUCTION**
Evaluation and reduction of drag
[AAAF PAPER NT 85-01] p 766 A86-48452
Reduction of turbulent drag - Turbulence manipulators
[AAAF PAPER NT 85-04] p 766 A86-48455
Theoretical and experimental analysis of separations on helicopter fuselages
[AAAF PAPER NT 85-08] p 766 A86-48458
Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983
International Aviation (selected articles)
[AD-A165298] p 783 N86-31528
- DRONE AIRCRAFT**
Design of a multivariable flutter control/gust load alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494
- DROPS (LIQUIDS)**
Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer
[ASME PAPER 86-GT-174] p 815 A86-48225
On the motion of spray drops in the wake of an agricultural aircraft p 777 A86-49441
- DUMMIES**
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738
- DURABILITY**
Environmental-durability testing — of Al alloy bonded aircraft structures p 845 A86-47719
Durability and damage tolerance assessment of the TF34-100 engine
[ASME PAPER 86-GT-38] p 812 A86-48125
Long endurance aircraft performance p 805 A86-49478
- DYNAMIC CHARACTERISTICS**
Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299
Dynamic aspects in the design of advanced rotor systems p 798 A86-48663
Topics in landing gear dynamics research at NASA Langley p 803 A86-49120
- DYNAMIC CONTROL**
Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064
On the handling qualities of flight vehicles through variable flight conditions p 836 N86-31592
- DYNAMIC MODELS**
Dynamics of a helicopter with a sling load
[AIAA PAPER 86-2288] p 831 A86-47709
Solid-beam model of a deformable aircraft for natural-vibration studies p 804 A86-49444
- DYNAMIC RESPONSE**
The dynamic response of a variable sweep aircraft in the course of changing geometry
[AIAA PAPER 86-2234] p 829 A86-47694
Dynamic response of the A.310 in flight to control-surface loading
[AAAF PAPER NT 85-18] p 797 A86-48487
Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis p 799 A86-48667
The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671
Dynamic identification procedure and lift certification of light aircraft and gliders
[ONERA-RT-12/1677-RY-090-R] p 809 N86-32429
- DYNAMIC STABILITY**
A certain type of self-oscillation of aircraft landing-gear wheels p 800 A86-48829
Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control p 833 A86-49039
- DYNAMIC STRUCTURAL ANALYSIS**
Limitations of statically unstable aircraft due to the effects of sensor noise, turbulence, and structural dynamics
[AIAA PAPER 86-2203] p 824 A86-47483
Structural dynamics research in a full-scale transport aircraft crash test p 785 A86-49053
Dynamic analysis: Correlation of theory with experiment — MSC/NASTRAN analysis of Westland 30 G-BGHF [RP661] p 851 N86-31917
- DYNAMIC TESTS**
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738
- E-2 AIRCRAFT**
Quantifying a propeller/engine power response rate mismatch p 796 A86-47801

E

ECONOMIC FACTORS

- Stripping and painting a plane - Technological and economic aspects p 760 A86-47614

EDDY CURRENTS

- Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing p 845 A86-47613

EFFECTIVE PERCEIVED NOISE LEVELS

- Method for determining the ISO-noise levels by simulated aircraft flight operations p 856 A86-49099

EFFICIENCY

- Advanced ATC - An aircraft perspective p 788 A86-49637

EIGENVALUES

- Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft [AIAA PAPER 86-2243] p 824 A86-47491
Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 N86-31590

EIGENVECTORS

- Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 N86-31590

EJECTION SEATS

- Flow stagnation as an advanced windblast protection technique - for ejection seat safety p 793 A86-47727
Evaluation of a pre-ejection upper torso retraction device p 793 A86-47728
The risk of collision in a two seat aircraft ejection p 783 A86-47730
Development of a controllable catapult for ejection seats p 793 A86-47733
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738
Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743
Evolution of the seawater activated release system (SEAWARS) - to prevent drownings after ejections from aircraft p 784 A86-47756
Sensor selection for the Boeing CREST ejection seat design p 793 A86-47757
Boeing control law for CREST demonstration ejection seat p 794 A86-47758

ELASTIC BODIES

- Modelling of rigid-body and elastic aircraft dynamics for flight control development [AIAA PAPER 86-2232] p 829 A86-47693

ELASTIC DAMPING

- Active flutter suppression p 832 A86-49004
Research on active suppression technology for wing/aileron flutter p 835 A86-49096

ELASTIC DEFORMATION

- Shimmy problems of landing gears caused by elastic deformation of tires p 803 A86-49118

ELASTOSTATICS

- Calculation of static elastic effects on a modern high performance fighter aircraft [AIAA PAPER 86-1771] p 777 A86-49577

ELECTRIC CHARGE

- Field observations of aircraft charging in convective clouds p 783 A86-47332

ELECTRIC CONTROL

- The M53 turbofan control system - A strong basis for the development of the future digital control systems p 817 A86-49088

ELECTRIC CORONA

- The energy requirements of an aircraft triggered discharge p 844 A86-47315
Corona threshold determination by three-stage physical modelling of aircraft p 792 A86-47333

ELECTRIC CURRENT

- Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296

- Induced current surface density after a direct lightning strike on an aircraft p 790 A86-47297

ELECTRIC DISCHARGES

- The energy requirements of an aircraft triggered discharge p 844 A86-47315

ELECTRIC FIELDS

- Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296

ELECTRIC SPARKS

- High voltage laboratory tests and lightning phenomena p 844 A86-47312

ELECTRICAL MEASUREMENT

- Aircraft lightning attachment at low altitudes p 791 A86-47317

ELECTRICAL PROPERTIES

- Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299

ELECTRO-OPTICS

- Contactless measurement of the torque of an aircraft engine p 849 A86-49145
Applications of thermal imager devices incl. modelling aspects [MBS-UD-462-85-OE] p 850 A86-50254

ELECTROMAGNETIC FIELDS

- Aircraft lightning attachment at low altitudes p 791 A86-47317

ELECTROMAGNETIC INTERACTIONS

- Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295

ELECTROMAGNETIC PROPERTIES

- Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning p 804 A86-49132
F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259

ELECTROMAGNETIC PULSES

- Comparison of published HEMP and natural lightning on the surface of an aircraft - High-Altitude Electromagnetic Pulse p 783 A86-47293
Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295
Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296
Design of a fast risetime lightning generator p 837 A86-47304
Implications associated with the operation of digital data processing in the presence of the relatively harsh EMP environments produced by lightning p 809 A86-47319

ELECTRONIC CONTROL

- Effect of time delay on flying qualities - An update [AIAA PAPER 86-2202] p 823 A86-47482
Development of HIDECA adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278

ELECTRONIC EQUIPMENT TESTS

- Potential of BITE's and what it means to aircraft maintenance p 759 A86-47607

ELECTROSTATIC CHARGE

- Experimental investigation of electrostatic fire and explosion accidents after aircraft landing and preventive design p 786 A86-49083

ELECTROSTATICS

- A wide bandwidth electrostatic field sensor for lightning research p 850 A86-50260

ELEVATORS (CONTROL SURFACES)

- An explicit adaptive flight control system based on the modified gain extended Kalman filter [AIAA PAPER 86-2158] p 823 A86-47465

ELLIPTIC DIFFERENTIAL EQUATIONS

- Elliptic generation of composite three-dimensional grids about realistic aircraft [NASA-TM-88240] p 763 N86-31527

ENGINE AIRFRAME INTEGRATION

- CFD for engine-airframe integration [ASME PAPER 86-GT-125] p 797 A86-48184
An approach to an integrated control system for a modern fighter aircraft engine [ASME PAPER 86-GT-277] p 816 A86-48296
Aircraft/engine integration for an advanced fighter considering mission specifics [ASME PAPER 86-GT-295] p 797 A86-48308
Utilization of computation and experiment for airframe propulsion integration development p 803 A86-49110
Time-averaged subsonic propeller flowfield calculations [AIAA PAPER 86-1807] p 778 A86-49584
New technology propulsion (ANT) for general aviation aircraft, phase 1 [BMFT-FB-W-85-031] p 820 N86-31589

ENGINE ANALYZERS

- Engine condition monitoring at KLM Royal Dutch Airlines [ASME PAPER 86-GT-300] p 816 A86-48312

ENGINE CONTROL

- Engine control reliability and durability improvement through accelerated mission environmental testing [ASME PAPER 86-GT-52] p 813 A86-48132
Development of HIDECA adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278
Aircraft/engine integration for an advanced fighter considering mission specifics [ASME PAPER 86-GT-295] p 797 A86-48308
The M53 turbofan control system - A strong basis for the development of the future digital control systems p 817 A86-49088
Digital engine control units for an fighter engine and an auxiliary power unit - A comparison p 817 A86-49089
Case studies of the effects on non-linearities on the accuracy of gas turbine control p 817 A86-49090

ENGINE DESIGN

- Flight testing of general electric high bypass engines evolution and revolution p 812 A86-47786
Engine component life prediction methodology for conceptual design investigations [ASME PAPER 86-GT-24] p 812 A86-48116
Operation of the CT7 turboprop engine as an auxiliary power unit (APU) [ASME PAPER 86-GT-28] p 812 A86-48119
Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage [ASME PAPER 86-GT-56] p 765 A86-48134
Developments in new gas turbine engine demonstrator programs [ASME PAPER 86-GT-80] p 813 A86-48148
Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan [ASME PAPER 86-GT-98] p 813 A86-48163
Stratified charge rotary engine for general aviation [ASME PAPER 86-GT-181] p 815 A86-48231
Power level influence on architecture of small helicopter turboshaft engines [ASME PAPER 86-GT-191] p 815 A86-48241
The GTC36-300 - A gas turbine auxiliary power unit for advanced technology transport aircraft [ASME PAPER 86-GT-285] p 816 A86-48302
Future trends in propulsion p 816 A86-48979
Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064
Advances in turbine technology p 817 A86-49079
The role of flow field computation in improving turbomachinery p 775 A86-49080
A propan status report p 817 A86-49091
Propan and turbofan - Antagonism or synthesis p 817 A86-49092
Potential application of advanced propulsion systems to civil aircraft p 802 A86-49093
The competitive and cooperative outlook for aircraft propulsion systems [AIAA PAPER 86-1134] p 857 A86-49571
Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation [AIAA PAPER 86-1452] p 818 A86-49611
Perspectives on dilution jet mixing - in creating temperature patterns at combustor exits in gas turbine engines [AIAA PAPER 86-1611] p 818 A86-49614
Advanced concepts in small helicopter engine air-cooled turbine design p 819 A86-50075
Aeropropulsion opportunities for the 21st century [NASA-TM-88817] p 819 N86-31585
A parametric study of a gas-generator air turbo ramjet (ATR) [NASA-TM-88808] p 819 N86-31586
An overview of the Small Engine Component Technology (SECT) studies [NASA-TM-88796] p 819 N86-31587

ENGINE INLETS

- An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806

ENGINE NOISE

- Measurements and computer modelling of engine exhaust noise in the cabin of single-engine aircraft p 798 A86-48594
Method for determining the ISO-noise levels by simulated aircraft flight operations p 856 A86-49099
Prediction of single-rotation prop-fan noise by a frequency domain scheme [ONERA, TP NO. 1986-100] p 818 A86-49125
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806

ENGINE PARTS

- Engine component life prediction methodology for conceptual design investigations [ASME PAPER 86-GT-24] p 812 A86-48116
Fabrication of high-alumina ceramic fixtures for jet engine repair applications [ASME PAPER 86-GT-46] p 846 A86-48130
Single crystal superalloys for turbine blades in advanced aircraft engines [ONERA, TP NO. 1986-102] p 843 A86-49077
An overview of the Small Engine Component Technology (SECT) studies [NASA-TM-88796] p 819 N86-31587
Short cracks in aerospace structures [NLR-MP-85054-U] p 851 N86-32781

ENGINE STARTERS

- A jet fuel starter and expendable turbojet [ASME PAPER 86-GT-1] p 812 A86-48101

ENGINE TESTS

- The use of surface static pressure data as a diagnostic tool in multistage compressor development [ASME PAPER 86-GT-3] p 812 A86-48103

- Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141
Subsonic/transonic stall flutter investigation of an
advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
Regression rate study for a solid fuel ramjet
p 818 A86-49113
Contactless measurement of the torque of an aircraft
engine p 849 A86-49145
A parametric study of a gas-generator air turbo ramjet
(ATR) p 819 N86-31586

ENVIRONMENT EFFECTS

- BK 117 flight tests for certification of an expanded flight
envelope
[MBB-UD-452-85-OE] p 805 A86-50253

ENVIRONMENTAL CONTROL

- Airport noise control strategies
[AD-A167977] p 840 N86-31602

ENVIRONMENTAL TESTS

- Environmental durability testing --- of Al alloy bonded
aircraft structures p 845 A86-47719
Engine control reliability and durability improvement
through accelerated mission environmental testing
[ASME PAPER 86-GT-52] p 813 A86-48132

EQUATIONS OF MOTION

- On the flight dynamics of aeroelastic vehicles
[AIAA PAPER 86-2077] p 828 A86-47666
Aerodynamic delay following control actuation in a
glider
[AIAA PAPER 86-2226] p 829 A86-47689

ESCAPE SYSTEMS

- Flow stagnation as an advanced windblast protection
technique --- for ejection seat safety p 793 A86-47727

- The risk of collision in a two seat aircraft ejection
p 783 A86-47730
Scott emergency escape breathing device - Evaluation
for use in Canadian forces aircraft p 784 A86-47731
Development of a controllable catapult for ejection
seats p 793 A86-47733
Emergency underwater escape from helicopters
p 784 A86-47745

- Evolution of the seawater activated release system
(SEAWARS) --- to prevent drownings after ejections from
aircraft p 784 A86-47756
Boeing control law for CREST demonstration ejection
seat p 794 A86-47758
Concept development of a canopy escape module
p 784 A86-47759

- Development of a new lightweight emergency escape
breathing device p 784 A86-47760

ETHERS

- The effect of the monoethers of dicarboxylic acids on
the antiwear properties of jet fuels p 843 A86-49963

EULER EQUATIONS OF MOTION

- Efficient solution of three-dimensional Euler equations
using embedded grids p 771 A86-49007
Free-vortex flow simulation using a three-dimensional
Euler aerodynamic method p 773 A86-49043

EUROPEAN AIRBUS

- Airbus-assembly concepts to improve productivity and
flexibility in aircraft construction p 761 A86-48999
Designing a load alleviation system for a modern civil
aircraft p 832 A86-49006
Automated systems for the manufacture of Airbus
Vertical Stabilizer Spar box in composite materials
p 762 A86-49067
Take-off prediction for the Airbus A300-600 and the A310
compared with flight test results p 804 A86-49121

EXHAUST EMISSION

- Conical grid plate flame stabilizers - Stability and
emissions for liquid fuels
[ASME PAPER 86-GT-156] p 842 A86-48210
Premixing gas and air to reduce NOx emissions with
existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211
A study on NOx emissions from gas turbine
combustor
[ASME PAPER 86-GT-168] p 814 A86-48220
Fuel effects on aircraft combustor emissions
[ASME PAPER 86-GT-212] p 815 A86-48252

EXHAUST FLOW SIMULATION

- The use of the magnetic aerohydrodynamic analogy
method to simulate three-dimensional flow past aircraft,
taking powerplant operation into account p 770 A86-48833

EXHAUST SYSTEMS

- Measurements and computer modelling of engine
exhaust noise in the cabin of single-engine aircraft
p 798 A86-48594

EXPERT SYSTEMS

- RT-BUILD - Automatic generation of Ada code for flight
control applications
[AIAA PAPER 86-2088] p 852 A86-47439

- A theory for fault-tolerant flight control combining expert
system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442
Experts system control of autonomous airborne
vehicle p 835 A86-49476
A knowledge-based expert system for scheduling of
airborne astronomical observations p 854 A86-49627

EXPLOSIONS

- Experimental investigation of electrostatic fire and
explosion accidents after aircraft landing and preventive
design p 786 A86-49083
Vulnerability methodology and protective measures for
aircraft fire and explosion hazards. Volume 1: Executive
summary
[AD-A167443] p 807 N86-31571

EXTERNAL STORES

- Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 N86-31568

F**F-106 AIRCRAFT**

- Research in lightning swept-stroke attachment patterns
and flight conditions with the NASA F-106B airplane
p 791 A86-47318
F-106 data summary and model results relative to threat
criteria and protection design analysis p 786 A86-50259

F-111 AIRCRAFT

- Flight control system development and flight test
experience with the F-111 mission adaptive wing aircraft
[AIAA PAPER 86-2237] p 824 A86-47489
Mission adaptive wing soars at NASA Facility
[P86-10182] p 806 N86-31583

F-14 AIRCRAFT

- Flight testing in the aircraft carrier environment
p 794 A86-47779
F-14A low-altitude asymmetric thrust simulation and
flight test program p 795 A86-47785

F-15 AIRCRAFT

- Development of HIDEAC adaptive engine control
systems
[ASME PAPER 86-GT-252] p 816 A86-48278

F-16 AIRCRAFT

- A jet fuel starter and expendable turbojet
[ASME PAPER 86-GT-1] p 812 A86-48101

F-18 AIRCRAFT

- Flight testing in the aircraft carrier environment
p 794 A86-47779
Avionics digital data acquisition system
p 810 A86-47790

F-27 AIRCRAFT

- Flight test instrumentation used in the Fokker F27 and
F28 development and certification flight program
[NLR-MP-84023-U] p 811 N86-32431

F-28 TRANSPORT AIRCRAFT

- Flight test instrumentation used in the Fokker F27 and
F28 development and certification flight program
[NLR-MP-84023-U] p 811 N86-32431

F-4 AIRCRAFT

- A study of aircraft cruise
[AIAA PAPER 86-2286] p 792 A86-47704

F-5 AIRCRAFT

- F-5E departure warning system algorithm development
and validation
[AIAA PAPER 86-2284] p 830 A86-47702

FABRICATION

- Low mass diffusion bonding tools
[AD-D012295] p 851 N86-32746

FAILURE ANALYSIS

- Aircraft control surface failure detection and isolation
using the OSGLR test --- orthogonal series generalized
likelihood ratio
[AIAA PAPER 86-2028] p 821 A86-47419
A parameter insensitive technique for aircraft sensor
fault analysis using eigenstructure assignment and
analytical redundancy
[AIAA PAPER 86-2029] p 809 A86-47420
Robust fault detection and isolation for a high
performance aircraft on STOL approach
[AIAA PAPER 86-2031] p 821 A86-47421
A theory for fault-tolerant flight control combining expert
system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442
An artificial intelligence approach to onboard fault
monitoring and diagnosis for aircraft applications
[AIAA PAPER 86-2093] p 853 A86-48577
Fibre optic damage detection in composite structures
p 848 A86-48988
Failure analysis of aircraft windshields subjected to bird
impact p 802 A86-49055

FAILURE MODES

- Multipath lightning protection for composite structure
integral fuel tank design p 790 A86-47308

FALSE ALARMS

- Design considerations for flight test of a fault inferring
nonlinear detection system algorithm for avionics
sensors
[AIAA PAPER 86-2030] p 810 A86-47511

FATIGUE (MATERIALS)

- Short cracks in aerospace structures
[NLR-MP-85054-U] p 851 N86-32781

FATIGUE LIFE

- Evaluation of damage tolerance requirements using a
probabilistic-based life approach
[ASME PAPER 86-GT-266] p 847 A86-48288
Fatigue fracture in landing gear steels
p 803 A86-49115
Selection of fatigue S-N curves within the framework
of new aircraft development p 804 A86-49137
A trade-off study of tilt rotor aircraft versus helicopters
using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575
Fatigue resistance of high quality steels under multiaxial
load
[ETN-86-97878] p 851 N86-32785

FATIGUE TESTING MACHINES

- Application of strain gauge amplifiers and computer
technology to the strength testing of aircraft
p 849 A86-49144
Fatigue resistance of high quality steels under multiaxial
load
[ETN-86-97878] p 851 N86-32785

FATIGUE TESTS

- Experience with stress analysis during airframe fatigue
tests p 840 A86-49143
Review of aeronautical fatigue investigations in the
Netherlands during the period March 1983 - February
1985
[NLR-MP-85025-U] p 851 N86-32779

FAULT TOLERANCE

- A theory for fault-tolerant flight control combining expert
system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442
Design considerations for flight test of a fault inferring
nonlinear detection system algorithm for avionics
sensors
[AIAA PAPER 86-2030] p 810 A86-47511

FEASIBILITY ANALYSIS

- Flight data recorders (FDR) and/or cockpit Voice
Recorders (CVR) in the Lockheed Orion P-3C Update 2
[ETN-86-97395] p 811 N86-31581
Studies for the application of a flexible weight and
balance (W/B) measuring facility for commercial aircraft
[BMFT-FB-W-85-029] p 840 N86-31604

FEEDBACK CONTROL

- Time scale analysis of a closed-loop discrete optimal
control system
[AIAA PAPER 86-1995] p 852 A86-47417
Single-state observer design considerations for aircraft
application
[AIAA PAPER 86-1996] p 852 A86-47418
Evaluation of total energy-rate feedback for glidescope
tracking in wind shear
[AIAA PAPER 86-2035] p 822 A86-47424
Performance characteristics of an adaptive controller
based on least-mean-square filters
[AIAA PAPER 86-2160] p 852 A86-47466
A design methodology for robust stabilizing controllers
[AIAA PAPER 86-2195] p 823 A86-47475
A preliminary investigation of H (infinity) optimization
[AIAA PAPER 86-2197] p 853 A86-47477
Application of eigenstructure assignment to design of
robust decoupling controllers in MIMO systems --- for
helicopters
[AIAA PAPER 86-2246] p 825 A86-47493
Design of a multivariable flutter control/gust load
alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494
Adaptive filtering of biodynamic stick feedthrough in
manipulation tasks on board moving platforms
[AIAA PAPER 86-2248] p 825 A86-47495
Identification of pilot dynamics in a system with a choice
of feedback structures
[AIAA PAPER 86-2250] p 825 A86-47496
Flight test experience and controlled impact of a large,
four-engine remotely piloted airplane p 794 A86-47781

- Near-optimal feedback control for three-dimensional
interceptions p 854 A86-48992
Optimal control laws for microburst encounter
p 834 A86-49070

- Preliminary control law and hardware designs for a ride
quality augmentation system for commuter aircraft. Phase
2
[NASA-CR-4014] p 836 N86-32440

- Servo-actuator for sampled-data feedback disturbance
rejection --- helicopters
[DFVLR-FB-86-08] p 837 N86-32446

FERROGRAPHY

- Analytical applications in the Army oil analysis program p 845 A86-47595

FIBER COMPOSITES

- Optimization of composite structures by controlled insertion or deletion of diverse fiber types p 844 A86-50122

FIBER OPTICS

- Fibre optic damage detection in composite structures p 848 A86-48988
Low cost inertial reference system based on fiber gyroscopes with GPS-aiding p 788 A86-49016
The development of a fibre optic data bus for helicopters p 811 A86-49131

FIBER REINFORCED COMPOSITES

- The development of aeroelastic tailoring in the United States p 805 A86-50111

FIGHTER AIRCRAFT

- Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331
Effect of head-up display dynamics on fighter flying qualities [AIAA PAPER 86-2206] p 792 A86-47485
Control reconfigurable combat aircraft flight control system development [AIAA PAPER 86-2236] p 824 A86-47488
Terminal control factors for the carrier landing task [AIAA PAPER 86-2251] p 825 A86-47497
An all-weather multimode landing system for tactical fighter aircraft [AIAA PAPER 86-2146] p 787 A86-47517
Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack [AIAA PAPER 86-2277] p 830 A86-47695
Vortex-induced effects on aircraft dynamics [AIAA PAPER 86-2279] p 830 A86-47697
Concept of automated aircraft guidance system for air-to-air missions [AIAA PAPER 86-2285] p 787 A86-47703
Boeing control law for CREST demonstration ejection seat p 794 A86-47758
Concept development of a canopy escape module p 784 A86-47759
Catapult holdback design examined p 838 A86-48041
Pumps for 8000 psi hydraulic systems examined p 846 A86-48042
Life cycle cost methodology for preliminary design evaluation [ASME PAPER 86-GT-37] p 812 A86-48124
An approach to an integrated control system for a modern fighter aircraft engine [ASME PAPER 86-GT-277] p 816 A86-48296
Aircraft/engine integration for an advanced fighter considering mission specifics [ASME PAPER 86-GT-295] p 797 A86-48308
Fighter power for the 1990s p 816 A86-48369
Near-optimal feedback control for three-dimensional interceptions p 854 A86-48992
Handling qualities for unstable combat aircraft p 833 A86-49025
The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056
Digital engine control units for an fighter engine and an auxiliary power unit - A comparison p 817 A86-49069
Calculation of static elastic effects on a modern high performance fighter aircraft [AIAA PAPER 86-1771] p 777 A86-49577
Transonic wave drag estimation and optimization using the nonlinear area rule [AIAA PAPER 86-1798] p 778 A86-49582
PN/S calculations for a fighter W/F at high-lift yaw conditions — parabolized Navier-Stokes computer code [AIAA PAPER 86-1829] p 779 A86-49588
Harrier the vifer — vectoring in forward flight as fighter aircraft combat maneuver p 763 A86-49681
An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 763 N86-31529
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies [AD-A167356] p 807 N86-31570
Multiple thermocouple testing device [AD-D012276] p 850 N86-31860
Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392
Aerodynamics of aircraft afterbody: Report of the working group on aerodynamics of aircraft afterbody [AGARD-AR-226] p 782 N86-32408

- Survivability considerations during aircraft conceptual design [AD-A168555] p 809 N86-32428

- TURBISTAN: A standard load sequence for aircraft engine disks [NLR-MP-85033-U] p 820 N86-32436

FILAMENT WINDING

- Optimization of composite structures by controlled insertion or deletion of diverse fiber types p 844 A86-50122

FINITE DIFFERENCE THEORY

- Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
Three-dimensional transonic flow computations on simple skewed grids [AIAA PAPER 86-1794] p 778 A86-49581
Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258

FINITE ELEMENT METHOD

- Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
Transmission design using finite element method analysis techniques p 847 A86-48658
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806
Dynamic analysis: Correlation of theory with experiment — MSC/NASTRAN analysis of Westland 30 G-BGHF [RP661] p 851 N86-31917
A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340 — propeller-driven aircraft [FFA-TN-1986-22] p 856 N86-33125

FINITE VOLUME METHOD

- Efficient solution of three-dimensional Euler equations using embedded grids p 771 A86-49007
Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045

FINS

- Manufacturing technology of composite torque box of vertical fin p 848 A86-49068

FIRE EXTINGUISHERS

- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies [AD-A167356] p 807 N86-31570
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary [AD-A167443] p 807 N86-31571
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants [AD-A167444] p 807 N86-31572
FIRE PREVENTION
Experimental investigation of electrostatic fire and explosion accidents after aircraft landing and preventive design p 786 A86-49083

FIRES

- Fireproof hydraulic brake system [AD-A167774] p 786 N86-31549
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies [AD-A167356] p 807 N86-31570
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary [AD-A167443] p 807 N86-31571
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants [AD-A167444] p 807 N86-31572
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests [AD-A167445] p 807 N86-31573

FIXED WINGS

- The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671

FLAME RETARDANTS

- Fireproof hydraulic brake system [AD-A167774] p 786 N86-31549

FLAME STABILITY

- Conical grid plate flame stabilizers - Stability and emissions for liquid fuels [ASME PAPER 86-GT-156] p 842 A86-48210

- Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer [ASME PAPER 86-GT-174] p 815 A86-48225

FLAMMABILITY

- Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure p 785 A86-48989

FLAPS (CONTROL SURFACES)

- Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830
Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows [ONERA, TP NO. 1986-101] p 776 A86-49106

FLAT PLATES

- Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783

FLEXIBLE BODIES

- Oscillating wings and bodies with flexure in supersonic flow Applications of harmonic potential panel method p 776 A86-49108

- Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 N86-31590

FLIGHT ALTITUDE

- Characteristics of altitude error at reduced quantization [FAA/PM-86/35] p 811 N86-31580

FLIGHT CHARACTERISTICS

- Pitch rate sensitivity criterion for category C flight phases - Class IV aircraft [AIAA PAPER 86-2201] p 823 A86-47481
Effect of time delay on flying qualities - An update [AIAA PAPER 86-2202] p 823 A86-47482
Effect of head-up display dynamics on fighter flying qualities [AIAA PAPER 86-2206] p 792 A86-47485
Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672
The MIL-prime standard for aircraft flying qualities [AIAA PAPER 86-2131] p 828 A86-47677
Handling qualities and flight performance - Implication of the operational envelope p 799 A86-48672
Self-oscillatory regimes of aircraft motion during spin-roll coupling p 832 A86-48775
Determination of the statistical characteristics of aircraft motion during an automatic approach p 832 A86-48844

FLIGHT CONDITIONS

- Aircraft control surface failure detection and isolation using the OSGLR test — orthogonal series generalized likelihood ratio [AIAA PAPER 86-2028] p 821 A86-47419
Aircraft protection against lightning strikes p 806 A86-50347
On the handling qualities of flight vehicles through variable flight conditions [AD-A167727] p 836 N86-31592

FLIGHT CONTROL

- A stochastic decentralized flight control system [AIAA PAPER 86-1994] p 821 A86-47418
Time scale analysis of a closed-loop discrete optimal control system [AIAA PAPER 86-1995] p 852 A86-47417
Single-state observer design considerations for aircraft application [AIAA PAPER 86-1996] p 852 A86-47418
Evaluation of total energy-rate feedback for glidescope tracking in wind shear [AIAA PAPER 86-2035] p 822 A86-47424
Sensitivity analysis of high-order digital flight control systems using singular-value concepts [AIAA PAPER 86-2084] p 822 A86-47437
RT-BUILD - Automatic generation of Ada code for flight control applications [AIAA PAPER 86-2088] p 852 A86-47439
A theory for fault-tolerant flight control combining expert system and analytical redundancy concepts [AIAA PAPER 86-2092] p 822 A86-47442
Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator [AIAA PAPER 86-2205] p 787 A86-47519
The interpretation of flying qualities requirements for flight control design [AIAA PAPER 86-2249] p 826 A86-47523
Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control [AIAA PAPER 86-2017] p 826 A86-47652
Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676
Modelling of rigid-body and elastic aircraft dynamics for flight control development [AIAA PAPER 86-2232] p 829 A86-47693

- Flight test experience and controlled impact of a large, four-engine remotely piloted airplane p 794 A86-47781
- Airbus A 320 - New concept of aircraft control p 796 A86-47797
- Active flutter suppression p 832 A86-49004
- Design criteria for flight control systems p 833 A86-49023
- Handling qualities for unstable combat aircraft p 833 A86-49025
- Optimal control laws for microburst encounter p 834 A86-49070
- Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507
- Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563
- Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 N86-31590
- On the handling qualities of flight vehicles through variable flight conditions p 836 N86-31592
- Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042
- FLIGHT CREWS**
- Retrofit energy-absorbing crewseat for the SH-3 (S-61 series) Sea King helicopter p 793 A86-47736
- Development of a new lightweight emergency escape breathing device p 784 A86-47760
- Aircrew protection design, training and mission management for high altitude aerodynamic operations p 761 A86-47778
- FLIGHT HAZARDS**
- Ranging and azimuthal problems of an airborne crossed loop used as a single-station lightning locator p 809 A86-47325
- Take-off and landing in a downburst p 786 A86-49069
- Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning p 804 A86-49132
- F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259
- A wide bandwidth electrostatic field sensor for lightning research p 850 A86-50260
- FLIGHT INSTRUMENTS**
- Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations [NASA-TM-86779] p 789 N86-31551
- FLIGHT MANAGEMENT SYSTEMS**
- Thirty years with the jets: Commercial transport flight management systems - Past, present, and future [AIAA PAPER 86-2289] p 821 A86-47402
- A stochastic decentralized flight control system [AIAA PAPER 86-1994] p 821 A86-47416
- Design factors and considerations for a time-based flight management system [AIAA PAPER 86-2144] p 822 A86-47455
- Flight management concepts compatible with air traffic control p 788 A86-49018
- FLIGHT MECHANICS**
- Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers p 826 A86-47651
- On the flight dynamics of aeroelastic vehicles [AIAA PAPER 86-2077] p 828 A86-47666
- Unsteady aerodynamics - Fundamental aspects and applications to aircraft dynamics [AAAF PAPER NT 85-16] p 767 A86-48465
- Ground based helicopter simulation p 838 A86-48673
- Validation on nonstationary aerodynamics models for longitudinal aeroplane motion on the basis of flight measurements p 833 A86-49026
- FLIGHT OPTIMIZATION**
- Optimization and acceleration guidance of flight trajectories in a windshear [AIAA PAPER 86-2036] p 822 A86-47425
- Optimal descending, hypersonic turn to heading [AIAA PAPER 86-2134] p 841 A86-47679
- A study of aircraft cruise [AIAA PAPER 86-2286] p 792 A86-47704
- Optimal landing of a helicopter in autorotation [AIAA PAPER 86-2287] p 793 A86-47705
- Interior transition layers in flight path optimization [AIAA PAPER 86-2037] p 797 A86-48576
- Wind influence on the range of jet or propeller aircraft p 801 A86-48990
- Reducing fuel consumption by cyclic control p 832 A86-48991
- Optimization and gamma/theta guidance of flight trajectories in a windshear p 834 A86-49071
- A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP [AD-A167719] p 808 N86-31575

- FLIGHT PATHS**
- An all-weather multimode landing system for tactical fighter aircraft [AIAA PAPER 86-2146] p 787 A86-47517
- A robust adaptive flightpath reconstruction technique [AIAA PAPER 86-2018] p 826 A86-47653
- Flight simulation of MLS interception procedures applicable to laterally segmented approach paths [AIAA PAPER 86-2073] p 837 A86-47663
- Pilot evaluation of experimental flight trajectories in the near-terminal area [AIAA PAPER 86-2074] p 838 A86-47664
- Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672
- Angle-of-attack estimation for analysis of CAT encounters p 831 A86-47798
- Interior transition layers in flight path optimization [AIAA PAPER 86-2037] p 797 A86-48576
- Flight path reconstruction - A powerful tool for data compatibility check p 833 A86-49041
- Optimization and gamma/theta guidance of flight trajectories in a windshear p 834 A86-49071
- FLIGHT RECORDERS**
- The analysis of airline flight records for winds and performance with application to the Delta 191 accident [AIAA PAPER 86-2227] p 829 A86-47690
- Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2 [ETN-86-97395] p 811 N86-31581
- FLIGHT SAFETY**
- Simulation results of automatic restructurable flight control system concepts [AIAA PAPER 86-2032] p 821 A86-47422
- Obstacle warning radar for helicopters - An anthropotechnical problem p 787 A86-47769
- Airplane landing behaviors controlled by man-pilots p 835 A86-49244
- Characteristics of altitude error at reduced quantization [FAA/PM-86/35] p 811 N86-31580
- FLIGHT SIMULATION**
- MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation - for F-14 flight simulation [AIAA PAPER 86-2085] p 853 A86-47505
- Recent advances in Monte Carlo turbulence simulation --- for aircraft flight simulation p 792 A86-47636
- Use of flight simulation to develop terminal instrument procedures for transport category aircraft [AIAA PAPER 86-2072] p 837 A86-47662
- Flight simulation of MLS interception procedures applicable to laterally segmented approach paths [AIAA PAPER 86-2073] p 837 A86-47663
- Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672
- Flight simulation techniques with emphasis on the generation of high fidelity 6 DOF motion cues p 839 A86-49024
- A simulation facility for assessing the next generation of 4-D air traffic control procedures p 788 A86-49034
- Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392
- A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425
- Review of aeronautical fatigue investigations in the Netherlands during the period March 1983 - February 1985 [NLR-MP-85025-U] p 851 N86-32779
- Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042
- FLIGHT SIMULATORS**
- Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator [AIAA PAPER 86-2205] p 787 A86-47519
- The interpretation of flying qualities requirements for flight control design [AIAA PAPER 86-2249] p 826 A86-47523
- Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator [AIAA PAPER 86-2026] p 827 A86-47660
- Pilot evaluation of experimental flight trajectories in the near-terminal area [AIAA PAPER 86-2074] p 838 A86-47664
- Turbulence response matching in the NT-33A in-flight simulator [AIAA PAPER 86-2076] p 827 A86-47665
- Effects of time delay and pitch control sensitivity in the flared landing [AIAA PAPER 86-2075] p 831 A86-47706
- Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations [NASA-TM-86779] p 789 N86-31551

- Simulator scene display evaluation device [NASA-CASE-ARC-11504-1] p 840 N86-32447
- An improved optical viewing system for a flight simulator [MS-8025] p 840 N86-32448
- FLIGHT STABILITY TESTS**
- Parametric study of low Reynolds number processing/spinning incompressible flows --- applicable to flight stability of liquid-filled projectiles [AIAA PAPER 86-2027] p 827 A86-47661
- Loran C 1984 spring-summer stability [AD-A167867] p 789 N86-31555
- Identification of gust input and gust response characteristics from Do 28 TNT flight test data [ESA-TT-919] p 837 N86-32445
- FLIGHT TEST INSTRUMENTS**
- The application of energy techniques to propeller-driven airplanes [AD-A167113] p 807 N86-31569
- Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program [NLR-MP-84023-U] p 811 N86-32431
- FLIGHT TESTS**
- New methods for in-flight vibration testing p 820 A86-47369
- Flight test evaluation of techniques to predict longitudinal pilot induced oscillations [AIAA PAPER 86-2253] p 826 A86-47509
- Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors [AIAA PAPER 86-2030] p 810 A86-47511
- NASA B737 flight test results of the Total Energy Control System [AIAA PAPER 86-2143] p 826 A86-47516
- Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985, Proceedings p 794 A86-47776
- A proposed plane for the initial flight testing of a Rutan Aircraft Factory long-EZ and other light amateur experimental aircraft p 794 A86-47777
- Flight testing in the aircraft carrier environment p 794 A86-47779
- A minimum approach to flight testing p 810 A86-47780
- Flight test experience and controlled impact of a large, four-engine remotely piloted airplane p 794 A86-47781
- Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782
- Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783
- F-14A low-altitude asymmetric thrust simulation and flight test program p 795 A86-47785
- Flight testing of general electric high bypass engines evolution and revolution p 812 A86-47786
- Results of technology programs for general aviation aircraft at Dornier p 795 A86-47787
- Flight testing on customer aircraft with a portable airborne digital data system p 810 A86-47788
- Precise control surface position measurements for hysteresis and twist testing p 795 A86-47789
- From mainframe to micro - Structures and flutter testing at the Air Force Flight Test Center p 838 A86-47791
- Re-engine KC-135R/CFM56 flight test program - An overview p 795 A86-47793
- A new look at inflight loads on existing transport aircraft p 796 A86-47794
- X-29 Technology Demonstrator program status review p 796 A86-47795
- Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model p 796 A86-47800
- Flight flutter testing at Ames-Dryden p 797 A86-47802
- Test and flight evaluation of precision distance measuring equipment p 788 A86-49017
- Flight path reconstruction - A powerful tool for data compatibility check p 833 A86-49041
- Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057
- Method of analysing data on a swept wing aircraft in flight p 775 A86-49103
- Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121
- Details of analysis of airplane structure acoustic loading in flight testing p 804 A86-49129
- BK 117 flight tests for certification of an expanded flight envelope [MBB-UD-452-85-OE] p 805 A86-50253
- Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563
- Flight test of passive wing/store flutter suppression [NASA-TM-87766] p 806 N86-31568

- Aerial refueling evaluation of the CH-47D helicopter
[AD-A167575] p 808 N86-31574
- Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577
- Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program
[NLR-MP-84023-U] p 811 N86-32431
- FLIGHT TIME**
Advanced ATC - An aircraft perspective
p 788 A86-49637
- FLIR DETECTORS**
Applications of thermal imager devices incl. modelling aspects
[MBB-UD-482-85-OE] p 850 A86-50254
- Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779] p 789 N86-31551
- FLOW DEFLECTION**
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack
p 767 A86-48762
- FLOW DISTORTION**
Method for calculating subsonic ideal-gas flow past an aircraft
p 788 A86-48807
- FLOW DISTRIBUTION**
Theoretical and experimental analysis of separations on helicopter fuselages
[AAAF PAPER NT 85-08] p 766 A86-48458
- Calculation of flow over multielement airfoils at high lift
p 772 A86-49011
- Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer
p 775 A86-49074
- The role of flow field computation in improving turbomachinery
p 775 A86-49080
- Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg
[AIAA PAPER 86-1775] p 777 A86-49579
- Time-averaged subsonic propeller flowfield calculations
[AIAA PAPER 86-1807] p 778 A86-49584
- Elliptic generation of composite three-dimensional grids about realistic aircraft
[NASA-TM-88240] p 763 N86-31527
- FLOW EQUATIONS**
ATRAN3S: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535
- FLOW GEOMETRY**
Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack
p 770 A86-48825
- Transonic computations about complex configurations using coupled inner and outer flow equations
p 771 A86-49008
- Passive control of jets with indeterminate origins
p 780 A86-49807
- FLOW MEASUREMENT**
Development of an experimental correlation for transonic turbine flow
[ASME PAPER 86-GT-108] p 765 A86-48170
- Evaluation of the blade-to-blade flow from a high speed compressor rotor
[ASME PAPER 86-GT-117] p 765 A86-48176
- Airfoil trailing-edge flow measurements
p 780 A86-49803
- FLOW STABILITY**
The aerodynamic potential of anti-sound
p 855 A86-48977
- Passive control of jets with indeterminate origins
p 780 A86-49807
- FLOW THEORY**
An entropy correction method for unsteady full potential flows with strong shocks
[AIAA PAPER 86-1768] p 777 A86-49576
- Cancellation zone in supersonic lifting wing theory
p 780 A86-49824
- FLOW VELOCITY**
Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust
[AIAA PAPER 86-1809] p 778 A86-49585
- FLOW VISUALIZATION**
Visualization of dynamic stall controlled by large amplitude interrupted pitching motions
[AIAA PAPER 86-2281] p 764 A86-47699
- Method for the visualization of subsonic gas flows
p 769 A86-48808
- FLUTTER**
Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model
[AIAA PAPER 86-2242] p 824 A86-47490
- Design of a multivariable flutter control/gust load alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494
- Active flutter suppression
p 832 A86-49004
- Aeroelastic tailoring for flutter constraints
p 802 A86-49081
- Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592
- FLUTTER ANALYSIS**
Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft
[AIAA PAPER 86-2243] p 824 A86-47491
- Real-time flutter identification with close mode resolution
[AIAA PAPER 86-2019] p 827 A86-47654
- From mainframe to micro - Structures and flutter testing at the Air Force Flight Test Center
p 838 A86-47791
- Flight flutter testing at Ames-Dryden
p 797 A86-47802
- On the optimization of flutter characteristics of laminated anisotropic cylindrical shells
p 848 A86-49082
- Applications of potential theory computations to transonic aeroelasticity
p 775 A86-49105
- FLY BY WIRE CONTROL**
A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy
[AIAA PAPER 86-2029] p 809 A86-47420
- FLYING PLATFORMS**
Going where no man has gone before
p 762 A86-49443
- FOKKER AIRCRAFT**
On the way to extended noise reductions in propeller aircraft
[B8573887] p 857 N86-33126
- FORCE DISTRIBUTION**
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack
p 767 A86-48762
- FOREBODIES**
Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control
p 833 A86-49039
- Forebody vortex management for yaw control at high angles of attack
p 833 A86-49047
- FORMAT**
KRASH 85 user's guide: Input/output format, revision
[AD-A168946] p 787 N86-32416
- FRACTURE MECHANICS**
Fatigue fracture in landing gear steels
p 803 A86-49115
- FRACTURE STRENGTH**
Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures
p 853 A86-48760
- FREE FLOW**
A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure
[NAL-TRM-SE-8603] p 782 N86-32393
- FREEZING**
Impact of higher freeze point fuels on naval aircraft operations
[ASME PAPER 86-GT-262] p 843 A86-48285
- FRICTION DRAG**
The effect of the aspect ratio of the cylindrical section on the fuselage drag at transonic flight velocities
p 768 A86-48801
- FRICTION FACTOR**
Nonlinear dynamics or rotor/blade/casing rub interactions
[ASME PAPER 86-DE-6] p 818 A86-49620
- FUEL COMBUSTION**
Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels
[ASME PAPER 86-GT-163] p 843 A86-48216
- Fuel effects on aircraft combustor emissions
[ASME PAPER 86-GT-212] p 815 A86-48252
- Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation
[NASA-TM-87304] p 819 N86-31582
- FUEL CONSUMPTION**
The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation
p 816 A86-48757
- Reducing fuel consumption by cyclic control
p 832 A86-48991
- A propan status report
p 817 A86-49091
- A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575
- FUEL CONTROL**
Case studies of the effects on non-linearities on the accuracy of gas turbine control
p 817 A86-49090
- FUEL SPRAYS**
The performance of a reverse flow combustor using JP 10 fuel
[ASME PAPER 86-GT-146] p 814 A86-48202
- Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer
[ASME PAPER 86-GT-174] p 815 A86-48225
- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants
[AD-A167444] p 807 N86-31572
- FUEL SYSTEMS**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573
- FUEL TANKS**
Multipath lightning protection for composite structure integral fuel tank design
p 790 A86-47308
- Optical detection methods for testing of fuel tank lightning ignition hazards
p 791 A86-47309
- Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection
p 845 A86-47329
- Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary
[AD-A167443] p 807 N86-31571
- FUEL TESTS**
Live tests on static electricity in fuelling of aircraft
p 783 A86-47334
- Thermal decomposition of aircraft fuel
[ASME PAPER 86-GT-36] p 842 A86-48123
- Thermal stability concerns of Navy aviation fuel
[ASME PAPER 86-GT-94] p 842 A86-48159
- FUEL-AIR RATIO**
Premixing gas and air to reduce NO_x emissions with existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211
- FULL SCALE TESTS**
Structural dynamics research in a full-scale transport aircraft crash test
p 785 A86-49053
- Aeroacoustics at the German-Dutch wind tunnel
p 839 A86-49061
- FUNCTIONAL DESIGN SPECIFICATIONS**
Evaluation of damage tolerance requirements using a probabilistic-based life approach
[ASME PAPER 86-GT-266] p 847 A86-48288
- FUSELAGES**
The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator
p 790 A86-47306
- Theoretical and experimental analysis of separations on helicopter fuselages
[AAAF PAPER NT 85-08] p 766 A86-48458
- Rotor-fuselage dynamic coupling characteristics of helicopter air and ground resonance
p 799 A86-48666
- Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis
p 799 A86-48667
- Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions
p 799 A86-48738
- The effect of the aspect ratio of the cylindrical section on the fuselage drag at transonic flight velocities
p 768 A86-48801
- Experimental investigation of a boundary layer on a schematic aircraft model
p 769 A86-48824
- Method for the calculation and design of fuselage flaps made of composite materials
p 847 A86-48830
- Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure
p 785 A86-48989
- Optimum-Optimorum integrated wing-fuselage configuration for supersonic transport aircraft of second generation
p 801 A86-49010

GAS CHROMATOGRAPHY

An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography
p 844 A86-49964

GAS DYNAMICS

Method for the visualization of subsonic gas flows
p 769 A86-48808

GAS GENERATORS

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573

A parametric study of a gas-generator air turbo ramjet (ATR)
[NASA-TM-88808] p 819 N86-31586

GAS INJECTION

The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174

GAS TURBINE ENGINES

A jet fuel starter and expendable turbojet
[ASME PAPER 86-GT-1] p 812 A86-48101

Power turbine vane ring (PT6 engine) repair development
[ASME PAPER 86-GT-2] p 812 A86-48102

Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage
[ASME PAPER 86-GT-56] p 765 A86-48134

Developments in new gas turbine engine demonstrator programs
[ASME PAPER 86-GT-80] p 813 A86-48148

Acceleration performance of helicopter engines
[ASME PAPER 86-GT-121] p 814 A86-48180

Premixing gas and air to reduce NOx emissions with existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211

A study on NOx emissions from gas turbine combustor
[ASME PAPER 86-GT-168] p 814 A86-48220

A general computational method for simulation and prediction of transient behavior of gas turbines
[ASME PAPER 86-GT-180] p 815 A86-48230

The GTC36-300 - A gas turbine auxiliary power unit for advanced technology transport aircraft
[ASME PAPER 86-GT-285] p 816 A86-48302

Quality assurance in the reconditioning of gas turbine and compressor blading components
[ASME PAPER 86-GT-299] p 847 A86-48311

Advances in turbine technology p 817 A86-49079

Case studies of the effects on non-linearities on the accuracy of gas turbine control p 817 A86-49090

Unified constitutive materials model development and evaluation for high-temperature structural analysis applications --- for aircraft gas turbine engines p 849 A86-49133

A contribution to airworthiness certification of gas turbine disks p 849 A86-49136

Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation
[AIAA PAPER 86-1452] p 818 A86-49611

Perspectives on dilution jet mixing --- in creating temperature patterns at combustor exits in gas turbine engines
[AIAA PAPER 86-1611] p 818 A86-49614

Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation
[NASA-TM-87304] p 819 N86-31582

An overview of the Small Engine Component Technology (SECT) studies
[NASA-TM-88796] p 819 N86-31587

GAS TURBINES

Heat management in advanced aircraft gas turbine engines
[ASME PAPER 86-GT-76] p 813 A86-48144

Advanced concepts in small helicopter engine air-cooled turbine design p 819 A86-50075

GASEOUS FUELS

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573

GENERAL AVIATION AIRCRAFT

A proposed plane for the initial flight testing of a Rutan Aircraft Factory long-EZ and other light amateur experimental aircraft p 794 A86-47777

Results of technology programs for general aviation aircraft at Dornier p 795 A86-47787

Canard canard --- performance of light aircraft p 763 A86-49682

Weight estimation techniques for composite airplanes in general aviation industry
[NASA-CR-178163] p 781 N86-31531

GLIDE PATHS

Portable glide slope indicator
[AD-D012240] p 789 N86-31552

Analysis of a mirror deck landing aid
[AD-A167988] p 789 N86-31556

GLIDERS

Aerodynamic delay following control actuation in a glider
[AIAA PAPER 86-2226] p 829 A86-47689

Aircraft protection design, training and mission management for high altitude aerodynamic operations p 761 A86-47778

Dynamic identification procedure and lift certification of light aircraft and gliders
[ONERA-RT-12/1677-RY-090-R] p 809 N86-32429

GLOBAL POSITIONING SYSTEM

Low cost inertial reference system based on fiber gyros with GPS-aiding p 788 A86-49016

GROUND EFFECT (AERODYNAMICS)

The ground effects of a powered-lift STOL aircraft during landing approach p 795 A86-47784

GROUND HANDLING

Robotic systems concepts for the rapid turnaround of tactical aircraft in a biochemical environment p 761 A86-47763

Airports build for future traffic amid new security concern p 838 A86-48371

GROUND RESONANCE

The physical understanding on helicopter air and ground resonance p 798 A86-48660

Rotor-fuselage dynamic coupling characteristics of helicopter air and ground resonance p 799 A86-48666

Developments in helicopter ground vibration testing p 805 A86-49638

GROUND SUPPORT EQUIPMENT

Robotic systems concepts for the rapid turnaround of tactical aircraft in a biochemical environment p 761 A86-47763

GROUND TESTS

Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307

Lightning-induced transient test on a transport aircraft p 791 A86-47327

Developments in helicopter ground vibration testing p 805 A86-49638

GROUND WAVE PROPAGATION

Loran C 1984 spring-summer stability
[AD-A167867] p 789 N86-31555

GUIDANCE (MOTION)

Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers p 852 A86-47401

GUIDE VANES

The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation p 816 A86-48757

GUST ALLEVIATORS

Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model
[AIAA PAPER 86-2242] p 824 A86-47490

Design of a multivariable flutter control/gust load alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494

Designing a load alleviation system for a modern civil aircraft p 832 A86-49006

GUST LOADS

Prediction of gust loadings and alleviation at transonic speeds
[AIAA PAPER 86-0997] p 777 A86-49573

The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques --- aircraft design
[NLR-TR-85014-U] p 809 N86-32430

Identification of gust input and gust response characteristics from Do 28 TNT flight test data
[ESA-TT-919] p 837 N86-32445

GYROSCOPES

Frequency and time domain designs of a strapdown vertical determination system
[AIAA PAPER 86-2148] p 810 A86-47457

H

H-53 HELICOPTER

Dynamics of a helicopter with a sling load
[AIAA PAPER 86-2288] p 831 A86-47709

HANDLING EQUIPMENT

Robotic systems concepts for the rapid turnaround of tactical aircraft in a biochemical environment p 761 A86-47763

HARMONIC ANALYSIS

Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems
[AD-A167400] p 856 N86-32249

HARRIER AIRCRAFT

The INS wind calibration in climb algorithm p 796 A86-47799

Harrier the viffer --- vectoring in forward flight as fighter aircraft combat maneuver p 763 A86-49681

HAZARDS

Advisory Circular: Design considerations to protect fuel systems during a wheels-up landing
[FAA-AC/25-994-1] p 806 N86-31564

HEAD-UP DISPLAYS

Effect of head-up display dynamics on fighter flying qualities
[AIAA PAPER 86-2206] p 792 A86-47485

HEAT RESISTANT ALLOYS

Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads
[ASME PAPER 86-GT-172] p 815 A86-48224

Single crystal superalloys for turbine blades in advanced aircraft engines
[ONERA, TP NO. 1986-102] p 843 A86-49077

HEAT TRANSFER

Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads
[ASME PAPER 86-GT-172] p 815 A86-48224

HEAVING

The effect of heave damping (ZW) on helicopter handling qualities
[AIAA PAPER 86-2129] p 828 A86-47675

HELICOPTER CONTROL

Automated pole placement algorithm for multivariable optimal control synthesis
[AIAA PAPER 86-2196] p 852 A86-47476

Application of eigenstructure assignment to design of robust decoupling controllers in MIMO systems --- for helicopters
[AIAA PAPER 86-2246] p 825 A86-47493

Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator
[AIAA PAPER 86-2205] p 787 A86-47519

The effect of heave damping (ZW) on helicopter handling qualities
[AIAA PAPER 86-2129] p 828 A86-47675

Optimal landing of a helicopter in autorotation
[AIAA PAPER 86-2287] p 793 A86-47705

A study of stability and control of a hingeless rotor helicopter with non-uniform induced velocity field p 831 A86-48655

The physical understanding on helicopter air and ground resonance p 798 A86-48660

Handling qualities and flight performance - Implication of the operational envelope p 799 A86-48672

Civil helicopter handling qualities requirements for visual and instrument flight p 832 A86-48674

Servo-actuator for sampled-data feedback disturbance rejection --- helicopters
[DFVLR-FB-86-08] p 837 N86-32446

HELICOPTER DESIGN

Anthropometric conditions for the construction of a helicopter cockpit p 794 A86-47768

Can Europe meet the challenge of LHX? p 797 A86-48370

Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656

Computing codes for development of helicopter crashworthy structures and test substantiation p 798 A86-48657

Transmission design using finite element method analysis techniques p 847 A86-48658

Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659

Dynamic aspects in the design of advanced rotor systems p 798 A86-48663

Coupled aeroelastic hub loads reduction p 799 A86-48665

Ground based helicopter simulation p 838 A86-48673

Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load p 849 A86-49128

The development of a fibre optic data bus for helicopters p 811 A86-49131

Modern developments in rotorcraft technology
[MBB-UD-458-85-OE] p 805 A86-49509

Development of the BO 105 LS
[MBB-UD-456-85-OE] p 805 A86-50255

Structural design and analysis aspects of composite helicopter components
[MBB-UD-454-85-OE] p 806 A86-50256

Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter
[SNIAS-861-210-108] p 836 N86-32444

HELICOPTER ENGINES

- Acceleration performance of helicopter engines
[ASME PAPER 86-GT-121] p 814 A86-48180
- Particulate flow solutions through centrifugal impeller with two splitters
[ASME PAPER 86-GT-130] p 765 A86-48188
- Power level influence on architecture of small helicopter turbohaft engines
[ASME PAPER 86-GT-191] p 815 A86-48241
- Advanced concepts in small helicopter engine air-cooled turbine design p 819 A86-50075

HELICOPTER PERFORMANCE

- Obstacle warning radar for helicopters - An anthropotechnical problem p 787 A86-47769
- Use and maintenance of helicopters on the plateau - areas of China p 785 A86-48869
- Helicopter parameter identification technology research under the considerably disturbing condition p 831 A86-48670
- The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671
- Handling qualities and flight performance - Implication of the operational envelope p 799 A86-48672
- Civil helicopter handling qualities requirements for visual and instrument flight p 832 A86-48674
- Developments in helicopter ground vibration testing p 805 A86-48638
- BK 117 flight tests for certification of an expanded flight envelope
[MBB-UD-452-85-OE] p 805 A86-50253
- A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575

HELICOPTER WAKES

- A study of the rotor wake in nap-of-the-earth p 787 A86-48653
- Overview of helicopter wake and airloads technology p 767 A86-48654

HELICOPTERS

- Emergency underwater escape from helicopters p 784 A86-47745
- Advanced icing wind tunnel for flight test development of icing rate systems p 838 A86-47792
- Theoretical and experimental analysis of separations on helicopter fuselages
[AAAF PAPER NT 85-08] p 766 A86-48458
- The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985. Parts 1, 2, 3, 4, & 5 p 761 A86-48651
- The helicopter technology of China p 761 A86-48652
- Calculating method for Z - 9 helicopters mooring load p 799 A86-48668
- A study of helicopter main rotor noise in hover
[AIAA PAPER 86-1858] p 856 A86-49575
- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations
[AD-A167717] p 781 N86-31539
- Aerial refueling evaluation of the CH-47D helicopter
[AD-A167575] p 808 N86-31574
- Airborne intruder detection considerations
[DE86-006462] p 808 N86-31576
- Design of a vertical thrust stand for a remotely piloted model helicopter
[AD-A167811] p 840 N86-31598
- Dynamic analysis: Correlation of theory with experiment - MSC/NASTRAN analysis of Westland 30 G-BGHF [RP661] p 851 N86-31917
- Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems
[AD-A167400] p 856 N86-32249

HIGH ALTITUDE

- Comparison of published HEMP and natural lightning on the surface of an aircraft - High-Altitude Electromagnetic Pulse p 783 A86-47293
- Aircrew protection design, training and mission management for high altitude aerodynamic operations p 761 A86-47778

HIGH ALTITUDE PRESSURE

- Characteristics of altitude error at reduced quantization
[FAA/PM-86/35] p 811 N86-31580

HIGH ASPECT RATIO

- Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845

HIGH FREQUENCIES

- The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306

HIGH PRESSURE

- Pumps for 8000 psi hydraulic systems examined p 846 A86-48042

HIGH REYNOLDS NUMBER

- Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457
- A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers p 847 A86-48647
- Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983

HIGH SPEED

- The race for speed from the beginning of aviation to the present day p 761 A86-48980
- Calculations of high speed propeller performances using finite difference methods p 818 A86-49126

HIGH TEMPERATURE ENVIRONMENTS

- Elevated-temperature-resistant adhesives p 842 A86-47717
- Unified constitutive materials model development and evaluation for high-temperature structural analysis applications - for aircraft gas turbine engines p 849 A86-49133

HIGH TEMPERATURE TESTS

- Thermal decomposition of aircraft fuel
[ASME PAPER 86-GT-36] p 842 A86-48123

HIGH VOLTAGES

- High voltage laboratory tests and lightning phenomena p 844 A86-47312

HIGHLY MANEUVERABLE AIRCRAFT

- Calculation of static elastic effects on a modern high performance fighter aircraft
[AIAA PAPER 86-1771] p 777 A86-49577
- Harrier the viffer - vectoring in forward flight as fighter aircraft combat maneuver p 763 A86-49681

HOLOGRAPHIC INTERFEROMETRY

- Interferometric holographic cinematography
[ISL-CO-219/85] p 851 N86-31872

HONEYCOMB STRUCTURES

- Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830

HORIZONTAL TAIL SURFACES

- Stability and control of aircraft with manual all-moving tailplanes
[AIAA PAPER 86-2231] p 829 A86-47692

HOVERING

- A study of helicopter main rotor noise in hover
[AIAA PAPER 86-1858] p 856 A86-49575
- A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575
- Design of a vertical thrust stand for a remotely piloted model helicopter
[AD-A167811] p 840 N86-31598

HUBS

- Coupled aeroelastic hub loads reduction p 799 A86-48665

HUMAN FACTORS ENGINEERING

- The interpretation of flying qualities requirements for flight control design
[AIAA PAPER 86-2249] p 826 A86-47523
- Anthropometric conditions for the construction of a helicopter cockpit p 794 A86-47768

HYDRAULIC CONTROL

- The M53 turbopump control system - A strong basis for the development of the future digital control systems p 817 A86-49088

HYDRAULIC EQUIPMENT

- Pumps for 8000 psi hydraulic systems examined p 846 A86-48042

HYDRAULIC FLUIDS

- Fireproof hydraulic brake system
[AD-A167774] p 786 N86-31549

HYDROCARBON COMBUSTION

- The performance of a reverse flow combustor using JP 10 fuel
[ASME PAPER 86-GT-146] p 814 A86-48202

HYPERSONIC FLIGHT

- Optimal descending, hypersonic turn to heading
[AIAA PAPER 86-2134] p 841 A86-47679

HYPERSONIC FLOW

- Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783
- The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843
- The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps p 771 A86-48849
- The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174

HYPERSONIC VEHICLES

- Configuration and trajectory of hypersonic transport with aerothermodynamic control p 804 A86-49124

INDICATING INSTRUMENTS

HYPERSONICS

- High speed viscous flow calculations about complex configurations
[NASA-TM-88237] p 850 N86-31827

HYPERVELOCITY IMPACT

- Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141

HYSTERESIS

- Precise control surface position measurements for hysteresis and twist testing p 795 A86-47789

ICE FORMATION

- Advanced icing wind tunnel for flight test development of icing rate systems p 838 A86-47792
- NASA's aircraft icing analysis program p 786 A86-49107
- NASA's Aircraft Icing Analysis Program
[NASA-TM-88791] p 786 N86-31548
- In-flight photogrammetric measurement of wing ice accretions
[NASA-TM-87191] p 806 N86-31562
- Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels
[NASA-TM-87316] p 820 N86-31588

ICE PREVENTION

- NASA's Aircraft Icing Analysis Program
[NASA-TM-88791] p 786 N86-31548

IDEAL FLUIDS

- Flow of an ideal fluid in the core of a vortex sheet p 770 A86-48839

IDEAL GAS

- Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807

IMAGING TECHNIQUES

- Applications of thermal imager devices incl. modelling aspects
[MBB-UD-462-85-OE] p 850 A86-50254

IMPACT DAMAGE

- Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055

IMPACT RESISTANCE

- Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141
- Computing codes for development of helicopter crashworthy structures and test substantiation p 798 A86-48657

IMPACT TESTS

- Flight test experience and controlled impact of a large, four-engine remotely piloted airplane p 794 A86-47781
- Structural dynamics research in a full-scale transport aircraft crash test p 785 A86-49053
- A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054

IMPELLERS

- Particulate flow solutions through centrifugal impeller with two splitters
[ASME PAPER 86-GT-130] p 765 A86-48188

IMPULSE GENERATORS

- The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306
- Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307
- High voltage laboratory tests and lightning phenomena p 844 A86-47312

IN-FLIGHT MONITORING

- A new look at inflight loads on existing transport aircraft p 796 A86-47794
- Avionics fault data acquisition - A concept for civil transport aircraft p 810 A86-49051
- Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning p 804 A86-49132
- Application of strain gauge methods to determination of in-flight loads of structure groups of small transport aircraft p 811 A86-49149

INCOMPRESSIBLE FLOW

- Parametric study of low Reynolds number precessing/spinning incompressible flows - applicable to flight stability of liquid-filled projectiles
[AIAA PAPER 86-2027] p 827 A86-47661
- Method for calculating pressure distribution on the surfaces of wings with slit mechanization p 768 A86-48806
- An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen p 770 A86-48841

INDICATING INSTRUMENTS

- Multiple thermocouple testing device
[AD-D012276] p 850 N86-31860

INERTIAL NAVIGATION

- The INS wind calibration in climb algorithm
p 796 A86-47799
- Low cost inertial reference system based on fiber gyros with GPS-aiding
p 788 A86-49016
- INERTIAL REFERENCE SYSTEMS**
Low cost inertial reference system based on fiber gyros with GPS-aiding
p 788 A86-49016
- INFRARED IMAGERY**
Applications of thermal imager devices incl. modelling aspects
[M8B-UD-462-85-OE]
p 850 A86-50254
- INFRARED RADAR**
Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779]
p 789 A86-31551
- INLET FLOW**
Modelling of acoustic radiation problems associated with turbomachinery and rotating blades
p 855 A86-48597
Wave drag of a supersonic air intake at high subsonic velocities
p 770 A86-48834
- INLET TEMPERATURE**
Multiple thermocouple testing device
[AD-D012276]
p 850 A86-31880
- INPUT/OUTPUT ROUTINES**
KRASH 85 user's guide: Input/output format, revision
[AD-A168846]
p 787 A86-32416
- INSPECTION**
Supplemental inspections of aging aircraft
p 845 A86-47525
- INSTRUMENT ERRORS**
A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy
[AIAA PAPER 86-2029]
p 809 A86-47420
Characteristics of altitude error at reduced quantization
[FAA/PM-86/35]
p 811 A86-31580
- INSTRUMENT FLIGHT RULES**
Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator
[AIAA PAPER 86-2205]
p 787 A86-47519
Civil helicopter handling qualities requirements for visual and instrument flight
p 832 A86-48674
- INSTRUMENT LANDING SYSTEMS**
Evaluation of alternatives for an Army precision landing system
[AD-A167780]
p 789 A86-31554
- INTERACTIONAL AERODYNAMICS**
Control of wake structure behind an oscillating airfoil
[AIAA PAPER 86-2282]
p 764 A86-47700
An experimental study of turbulent wake/boundary layer mixing flows
p 772 A86-49014
Wake/boundary-layer interactions in two and three dimensions
p 773 A86-49032
Intersection of an oblique shock wave with a cylindrical afterbody
p 775 A86-49098
Prediction of gust loadings and alleviation at transonic speeds
[AIAA PAPER 86-0997]
p 777 A86-49573
Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837]
p 779 A86-49592
- INTERCEPTION**
Near-optimal feedback control for three-dimensional interceptions
p 854 A86-48992
- INVERSIONS**
A method for transonic inverse cascade design with a stream function equation
[ASME PAPER 86-GT-189]
p 766 A86-48239
- INVISCID FLOW**
An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen
p 770 A86-48841
- ITERATIVE SOLUTION**
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight
p 856 A86-49806
- J**
- JET AIRCRAFT**
Live tests on static electricity in fuelling of aircraft
p 783 A86-47334
Thirty years with the jets: Commercial transport flight management systems - Past, present, and future
[AIAA PAPER 86-2289]
p 821 A86-47402
Wind influence on the range of jet or propeller aircraft
p 801 A86-48990
An experimental study of a three lifting surface configuration
p 775 A86-49104
Multiple thermocouple testing device
[AD-D012276]
p 850 A86-31860

- Survivability considerations during aircraft conceptual design
[AD-A168555]
p 809 A86-32428
- JET AIRCRAFT NOISE**
Use of acoustic intensity measurements in the characterization of jet noise sources
p 855 A86-48740
Prediction of single-rotation prop-fan noise by a frequency domain scheme
[ONERA, TP NO. 1986-100]
p 818 A86-49125
Noise control characteristics of synchrophasing. II - Experimental investigation — on aircraft fuselage model
p 805 A86-49808
- JET ENGINE FUELS**
A jet fuel starter and expendable turbojet
[ASME PAPER 86-GT-1]
p 812 A86-48101
Impact of higher freeze point fuels on naval aircraft operations
[ASME PAPER 86-GT-262]
p 843 A86-48285
The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels
p 843 A86-49963
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary
[AD-A167443]
p 807 A86-31571
- JET ENGINES**
Fabrication of high-alumina ceramic fixtures for jet engine repair applications
[ASME PAPER 86-GT-48]
p 846 A86-48130
- JET EXHAUST**
Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust
[AIAA PAPER 86-1809]
p 778 A86-49585
- JET FLOW**
Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust
[AIAA PAPER 86-1809]
p 778 A86-49585
Passive control of jets with indeterminate origins
p 780 A86-49807
- JET MIXING FLOW**
Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack
p 770 A86-48825
Perspectives on dilution jet mixing — in creating temperature patterns at combustor exits in gas turbine engines
[AIAA PAPER 86-1611]
p 818 A86-49614
Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems
p 780 A86-49804
- JET PROPULSION**
Aeropropulsion opportunities for the 21st century
[NASA-TM-88817]
p 819 A86-31585
- JET THRUST**
F-14A low-altitude asymmetric thrust simulation and flight test program
p 795 A86-47785
- JET VANES**
Power turbine vane ring (PT6 engine) repair development
[ASME PAPER 86-GT-2]
p 812 A86-48102
- K**
- KALMAN FILTERS**
Frequency and time domain designs of a strapdown vertical determination system
[AIAA PAPER 86-2148]
p 810 A86-47457
An explicit adaptive flight control system based on the modified gain extended Kalman filter
[AIAA PAPER 86-2158]
p 823 A86-47465
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors
[AIAA PAPER 86-2030]
p 810 A86-47511
Real-time flutter identification with close mode resolution
[AIAA PAPER 86-2019]
p 827 A86-47654
- KEROSENE**
Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer
[ASME PAPER 86-GT-174]
p 815 A86-48225
- KINETIC THEORY**
The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps
p 771 A86-48849
- KIRCHHOFF LAW**
Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme
p 769 A86-48822

L-1011 AIRCRAFT

- The analysis of airline flight records for winds and performance with application to the Delta 191 accident
[AIAA PAPER 86-2227]
p 829 A86-47690
- LAMINAR BOUNDARY LAYER**
Acoustic effect on stall hysteresis for low Reynolds number laminar flow
p 855 A86-47971
Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing
[AAAF PAPER NT 85-03]
p 786 A86-48454
Wing laminar boundary layer in the presence of a propeller slipstream
p 776 A86-49122
- LAMINAR FLOW**
Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme
p 769 A86-48822
High speed viscous flow calculations about complex configurations
[NASA-TM-88237]
p 850 A86-31827
- LAMINAR FLOW AIRFOILS**
Thick supercritical airfoils with low drag and NLF capability
p 771 A86-48981
Investigations on high Reynolds number laminar flow airfoils
p 771 A86-48983
Computation of the potential flow over airfoils with cusped or thin trailing edges
p 780 A86-49823
Laminar flow research applicable to subsonic aircraft
p 781 A86-50269
- LAMINATES**
Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading
p 848 A86-49040
On the optimization of flutter characteristics of laminated anisotropic cylindrical shells
p 848 A86-49082
- LANDING AIDS**
Optimal landing of a helicopter in autorotation
[AIAA PAPER 86-2287]
p 793 A86-47705
Portable glide slope indicator
[AD-D012240]
p 789 A86-31552
- LANDING GEAR**
A certain type of self-oscillation of aircraft landing-gear wheels
p 800 A86-48829
Fatigue fracture in landing gear steels
p 803 A86-49115
New design procedures applied to landing gear development
p 803 A86-49117
Shimmy problems of landing gears caused by elastic deformation of tires
p 803 A86-49118
Topics in landing gear dynamics research at NASA Langley
p 803 A86-49120
Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear — Russian book
p 804 A86-49288
Studies for the application of a flexible weight and balance (W/B) measuring facility for commercial aircraft
[BMFT-FB-W-85-029]
p 840 A86-31604
Six degree of freedom simulation software
[NAL-PD-SE-8614]
p 854 A86-33042
- LANDING LOADS**
A certain type of self-oscillation of aircraft landing-gear wheels
p 800 A86-48829
Measurements of landing gear loads of a commuter airliner
p 803 A86-49119
- LANDING SIMULATION**
Flight evaluation of a precision landing task for a powered-lift STOL aircraft
[AIAA PAPER 86-2130]
p 828 A86-47676
Investigations in landing process of aircraft by means of the Monte-Carlo method
[ESA-TT-951]
p 808 A86-31578
- LANDING SPEED**
The ground effects of a powered-lift STOL aircraft during landing approach
p 795 A86-47784
- LASER DOPPLER VELOCIMETERS**
Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer
p 775 A86-49074
The F2 wind tunnel of the Fauga-Mauzac Test Center
[ONERA, TP NO. 1986-104]
p 839 A86-49075
- LATERAL CONTROL**
Use of hinged strakes for lateral control at high angles of attack
[AIAA PAPER 86-2278]
p 830 A86-47696
Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2
[NASA-CR-4014]
p 836 A86-32440
- LEADING EDGE FLAPS**
Analysis of the vortical flow around a 60 degree delta wing with vortex flap
p 774 A86-49050
- LEADING EDGES**
Aerodynamics of delta wings with leading edge blowing
[AIAA PAPER 86-2230]
p 764 A86-47691

- Leading edge vortex flow over a 75 degree-swept delta wing
Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
- Free-vortex flow simulation using a three-dimensional Euler aerodynamic method
p 773 A86-49043
- Effects of spanwise blowing on pressure distribution and leading-edge vortex stability
p 774 A86-49046
- LEAST SQUARES METHOD**
Performance characteristics of an adaptive controller based on least-mean-square filters
[AIAA PAPER 86-2180] p 852 A86-47466
- LENS DESIGN**
An improved optical viewing system for a flight simulator
[MS-8025] p 840 N86-32448
- LEVERS**
Design of a nonlinear lever-type mechanism for aircraft control systems
p 835 A86-49139
- LIFE (DURABILITY)**
Comparison of methods for lifetime calculations of highly loaded aero-engine discs
[ASME PAPER 86-GT-102] p 814 A86-48165
- Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads
[ASME PAPER 86-GT-172] p 815 A86-48224
- LIFE CYCLE COSTS**
A jet fuel starter and expendable turbojet
[ASME PAPER 86-GT-1] p 812 A86-48101
- Life cycle cost methodology for preliminary design evaluation
[ASME PAPER 86-GT-37] p 812 A86-48124
- LIFE SUPPORT SYSTEMS**
Aircrew protection design, training and mission management for high altitude aerodynamic operations
p 761 A86-47778
- LIFT**
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack
p 767 A86-48782
- Calculation of flow over multielement airfoils at high lift
p 772 A86-49011
- The high lift development of the A320 aircraft
p 772 A86-49012
- The prediction of lift inferred from downstream vorticity measurements
p 775 A86-49102
- On the computation of wing lift interference caused by high bypass engines
p 776 A86-49109
- PN/S calculations for a fighter W/F at high-lift yaw conditions - parabolized Navier-Stokes computer code
[AIAA PAPER 86-1829] p 779 A86-49588
- Cancellation zone in supersonic lifting wing theory
p 780 A86-49824
- LIFT AUGMENTATION**
Trapping of a free vortex by airfoils with surface suction
p 780 A86-49801
- LIFT DEVICES**
The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account
p 770 A86-48833
- LIFT DRAG RATIO**
An experimental study of a three lifting surface configuration
p 775 A86-49104
- LIFTING BODIES**
An experimental study of a three lifting surface configuration
p 775 A86-49104
- LIGHT AIRCRAFT**
A proposed plane for the initial flight testing of a Rutan Aircraft Factory long-EZ and other light amateur experimental aircraft
p 794 A86-47777
- Canard canard - performance of light aircraft
p 783 A86-49682
- Dynamic identification procedure and lift certification of light aircraft and gliders
[ONERA-RT-12/1677-RY-090-R] p 809 N86-32429
- LIGHT SOURCES**
Portable glide slope indicator
[AD-D012240] p 789 N86-31552
- LIGHTNING**
International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings
p 844 A86-47292
- Comparison of published HEMP and natural lightning on the surface of an aircraft - High-Altitude Electromagnetic Pulse
p 783 A86-47293
- Electromagnetic interaction of external impulse fields with aircraft
p 790 A86-47295
- Induced surface currents and fields on a conducting body by a lightning strike (frequency domain)
p 844 A86-47296
- Induced current surface density after a direct lightning strike on an aircraft
p 790 A86-47297
- Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties
p 783 A86-47299
- Design of a fast risetime lightning generator
p 837 A86-47304
- Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system
p 790 A86-47305
- The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator
p 790 A86-47306
- Lightning simulation tests on FAA CV-580 lightning research aircraft
p 790 A86-47307
- Optical detection methods for testing of fuel tank lightning ignition hazards
p 791 A86-47309
- High voltage laboratory tests and lightning phenomena
p 844 A86-47312
- Aircraft lightning attachment at low altitudes
p 791 A86-47317
- Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane
p 791 A86-47318
- Implications associated with the operation of digital data processing in the presence of the relatively harsh EMP environments produced by lightning
p 809 A86-47319
- Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning
p 804 A86-49132
- F-106 data summary and model results relative to threat criteria and protection design analysis
p 786 A86-50259
- A wide bandwidth electrostatic field sensor for lightning research
p 850 A86-50260
- LIGHTNING SUPPRESSION**
Multipath lightning protection for composite structure integral fuel tank design
p 790 A86-47308
- The energy requirements of an aircraft triggered discharge
p 844 A86-47315
- Ranging and azimuthal problems of an airborne crossed loop used as a single-station lightning locator
p 809 A86-47325
- Lightning-induced transient test on a transport aircraft
p 791 A86-47327
- Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection
p 845 A86-47329
- Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet
p 792 A86-47331
- Aspects of lightning protection schemes for radomes
p 792 A86-47338
- Aircraft protection against lightning strikes
p 806 A86-50347
- LIKELIHOOD RATIO**
Aircraft control surface failure detection and isolation using the OSGLR test - orthogonal series generalized likelihood ratio
[AIAA PAPER 86-2028] p 821 A86-47419
- LIMBS (ANATOMY)**
Flow stagnation as an advanced windblast protection technique - for ejection seat safety
p 793 A86-47727
- LINEAR SYSTEMS**
Sensitivity analysis of high-order digital flight control systems using singular-value concepts
[AIAA PAPER 86-2084] p 822 A86-47437
- A design methodology for robust stabilizing controllers
[AIAA PAPER 86-2195] p 823 A86-47475
- Automated pole placement algorithm for multivariable optimal control synthesis
p 852 A86-47476
- LININGS**
Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation
[AIAA PAPER 86-1452] p 818 A86-49611
- Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation
[NASA-TM-87304] p 819 N86-31582
- LIQUID CHROMATOGRAPHY**
An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography
p 844 A86-49964
- LIQUID FILLED SHELLS**
Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660
- Parametric study of low Reynolds number precessing/spinning incompressible flows - applicable to flight stability of liquid-filled projectiles
[AIAA PAPER 86-2027] p 827 A86-47661
- LIQUID FUELS**
Conical grid plate flame stabilizers - Stability and emissions for liquid fuels
[ASME PAPER 86-GT-156] p 842 A86-48210
- LOADS (FORCES)**
Comparison of methods for lifetime calculations of highly loaded aero-engine discs
[ASME PAPER 86-GT-102] p 814 A86-48165
- Dynamic response of the A310 in flight to control-surface loading
[AAAF PAPER NT 85-18] p 797 A86-48467
- Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load
p 849 A86-49128
- TURBISTAN: A standard load sequence for aircraft engine discs**
[NLR-MP-85033-U] p 820 N86-32436
- Review of aeronautical fatigue investigations in the Netherlands during the period March 1983 - February 1985
[NLR-MP-85025-U] p 851 N86-32779
- LONGITUDINAL CONTROL**
Synthesis of an adaptive flight controller under unknown deterministic disturbances
[AIAA PAPER 86-2157] p 823 A86-47464
- A preliminary investigation of H (infinity) optimization
[AIAA PAPER 86-2197] p 853 A86-47477
- Effects of time delay and pitch control sensitivity in the flared landing
[AIAA PAPER 86-2075] p 831 A86-47706
- LONGITUDINAL STABILITY**
Identification of unsteady response in rudders at low velocities
[AAAF PAPER NT 85-19] p 797 A86-48468
- LORAN C**
Loran C 1984 spring-summer stability
[AD-A167867] p 789 N86-31555
- LOUDSPEAKERS**
Interferometric holographic cinematography
[ISL-CO-219/85] p 851 N86-31872
- LOW ALTITUDE**
Aircraft lightning attachment at low altitudes
p 791 A86-47317
- F-14A low-altitude asymmetric thrust simulation and flight test program
p 795 A86-47785
- LOW ASPECT RATIO WINGS**
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack
p 767 A86-48762
- LOW FREQUENCIES**
Interferometric holographic cinematography
[ISL-CO-219/85] p 851 N86-31872
- LOW PRESSURE**
Subsonic/transonic stall flutter investigation of an advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
- LOW REYNOLDS NUMBER**
Parametric study of low Reynolds number precessing/spinning incompressible flows - applicable to flight stability of liquid-filled projectiles
[AIAA PAPER 86-2027] p 827 A86-47661
- Acoustic effect on stall hysteresis for low Reynolds number laminar flow
p 855 A86-47971
- Aspect ratio effects on wings at low Reynolds numbers
p 782 N86-32390
- LOW SPEED**
F-14A low-altitude asymmetric thrust simulation and flight test program
p 795 A86-47785
- On the duration of low speed dynamic stall
p 773 A86-49033
- Low-speed aerodynamics of apex fences on a tailless delta configuration
[AIAA PAPER 86-1838] p 779 A86-49593
- LOW SPEED STABILITY**
Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip
[NASA-TM-87722] p 781 N86-31532
- LOW SPEED WIND TUNNELS**
Advanced icing wind tunnel for flight test development of icing rate systems
p 838 A86-47792
- LOW VISIBILITY**
Laser communication through low-visibility atmosphere for aircraft application
p 788 A86-48581
- LUBRICATING OILS**
Analytical applications in the Army oil analysis program
p 845 A86-47595
- An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography
p 844 A86-49964

M

MACH NUMBER

- The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle
p 770 A86-48843

MAINTAINABILITY

Maintainability optimization - The future challenge -- for aircraft maintenance p 762 A86-49052

MAINTENANCE

Quality assurance in the reconditioning of gas turbine and compressor blading components [ASME PAPER 86-GT-299] p 847 A86-48311

MAN MACHINE SYSTEMS

Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495

Identification of pilot dynamics in a system with a choice of feedback structures [AIAA PAPER 86-2250] p 825 A86-47496

A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations [ESA-TT-928] p 789 N86-31558

MANAGEMENT INFORMATION SYSTEMS
An infrastructure for information processing for computer aided design [NLR-MP-85038-U] p 854 N86-33054

MANAGEMENT PLANNING
Planning for minimum overhaul time p 760 A86-47618

MANDRELS
Low mass diffusion bonding tools [AD-D012295] p 851 N86-32746

MANEUVERABILITY
Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782

MANIPULATORS
Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495

MANUAL CONTROL
Cooperative synthesis of control and display augmentation [AIAA PAPER 86-2204] p 853 A86-47484

MANUALS
User's manual for the Falcon system -- Falcon research aircraft [ESA-TT-936] p 808 N86-31579

MANUFACTURING
Case studies in aircraft manufacturing automation p 762 A86-49000

Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials p 762 A86-49067

Manufacturing technology of composite torque box of vertical fin p 848 A86-49068

MAPPING
Spherical mapping and analysis of aircraft angles for maneuvering flight [AIAA PAPER 86-2283] p 830 A86-47701

MATHEMATICAL MODELS
A robust adaptive flightpath reconstruction technique [AIAA PAPER 80-2018] p 826 A86-47653

Helicopter parameter identification technology research under the considerably disturbing condition p 831 A86-48670

Precise solution for rational transfer parameters of flight vehicles p 801 A86-49022

Validation on nonstationary aerodynamics models for longitudinal aeroplane motion on the basis of flight measurements p 833 A86-49026

A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425

MAXIMUM LIKELIHOOD ESTIMATES
A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure [NAL-TRM-SE-8603] p 782 N86-32393

MEAN SQUARE VALUES
Performance characteristics of an adaptive controller based on least-mean-square filters [AIAA PAPER 86-2160] p 852 A86-47466

METAL BONDING
Adhesive selection from the user's viewpoint p 841 A86-47715

METAL FATIGUE
Fatigue fracture in landing gear steels p 803 A86-49115

METAL JOINTS
Structural analysis of adhesive-bonded joints p 846 A86-47722

METAL SURFACES
Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295

Residual strength prediction for planked wing tension surfaces [AIAA PAPER 86-0941] p 849 A86-49572

METALS
Plastic or metal - The judgement factors -- for selecting aircraft construction material p 762 A86-49037

METEOROLOGICAL FLIGHT

Field observations of aircraft charging in convective clouds p 783 A86-47332

User's manual for the Falcon system -- Falcon research aircraft [ESA-TT-936] p 808 N86-31579

METHODOLOGY
A methodology for evaluating the operational performance of an aircraft in a tactical environment [AIAA PAPER 86-2095] p 759 A86-47444

Life cycle cost methodology for preliminary design evaluation [ASME PAPER 86-GT-37] p 812 A86-48124

MICROBURSTS
Optimal control laws for microburst encounter p 834 A86-49070

MICROCOMPUTERS
From mainframe to micro - Structures and flutter testing at the Air Force Flight Test Center p 838 A86-47791

MICROPHONES
Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA [ONERA-RT-19/3463-AYP] p 841 N86-32451

MICROPROCESSORS
Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743

MICROWAVE LANDING SYSTEMS
Use of flight simulation to develop terminal instrument procedures for transport category aircraft [AIAA PAPER 86-2072] p 837 A86-47662

Flight simulation of MLS interception procedures applicable to laterally segmented approach paths [AIAA PAPER 86-2073] p 837 A86-47663

Analysis and simulation of the MLS landing signal - Echo separation -- French thesis p 788 A86-48564

Test and flight evaluation of precision distance measuring equipment p 788 A86-49017

Evaluation of alternatives for an Army precision landing system [AD-A187780] p 789 N86-31554

MIDAIR COLLISIONS
Air safety: Federal Aviation Administration's role in developing mid-air collision avoidance back-up systems [PB86-197506] p 787 N86-32418

MILITARY AIRCRAFT
Flight test evaluation of techniques to predict longitudinal pilot induced oscillations [AIAA PAPER 86-2253] p 826 A86-47509

The MIL-prime standard for aircraft flying qualities [AIAA PAPER 86-2131] p 828 A86-47677

Sensor selection for the Boeing CREST ejection seat design p 793 A86-47757

Robotic systems concepts for the rapid turnaround of tactical aircraft in a biochemical environment p 761 A86-47763

Impact of higher freeze point fuels on naval aircraft operations [ASME PAPER 86-GT-262] p 843 A86-48285

The British Aerospace Experimental Aircraft Programme and the role of system development cockpits p 801 A86-48996

Going where no man has gone before p 762 A86-49443

Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2 [ETN-86-97395] p 811 N86-31581

MILITARY HELICOPTERS
Can Europe meet the challenge of LHX? p 787 A86-48370

MILITARY TECHNOLOGY
An all-weather multimode landing system for tactical fighter aircraft [AIAA PAPER 86-2146] p 787 A86-47517

Going where no man has gone before p 762 A86-49443

MIRRORS
Analysis of a mirror deck landing aid [AD-A167988] p 789 N86-31556

MISSILE CONTROL
Prediction of the aerodynamic characteristics of flight vehicles in large unsteady maneuvers p 834 A86-49048

MISSION ADAPTIVE WINGS
Mission adaptive wing soars at NASA Facility [PB86-10182] p 806 N86-31563

MISSION PLANNING
A methodology for evaluating the operational performance of an aircraft in a tactical environment [AIAA PAPER 86-2095] p 759 A86-47444

MODAL RESPONSE
Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 N86-31590

MODEL REFERENCE ADAPTIVE CONTROL

Performance characteristics of an adaptive controller based on least-mean-square filters [AIAA PAPER 86-2160] p 852 A86-47466

Model-following control for an oblique-wing aircraft [AIAA PAPER 86-2244] p 824 A86-47492

MODULES
Concept development of a canopy escape module p 784 A86-47759

Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials p 762 A86-49067

MONITORS
Development of a takeoff performance monitoring system [NASA-TM-89001] p 835 N86-31591

MONOCOQUE STRUCTURES
Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656

MONOPULSE RADAR
Secondary radar leads - Monopulse points the way p 787 A86-48372

MONTE CARLO METHOD
Recent advances in Monte Carlo turbulence simulation -- for aircraft flight simulation p 792 A86-47836

An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 763 N86-31529

Investigations in landing process of aircraft by means of the Monte-Carlo method [ESA-TT-951] p 808 N86-31578

MOORING
Calculating method for Z - 9 helicopters mooring load p 799 A86-48668

MOTION SIMULATION
Flight simulation techniques with emphasis on the generation of high fidelity 6 DOF motion cues p 839 A86-49024

MIRCA AIRCRAFT
Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783

MULTISENSOR APPLICATIONS
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors [AIAA PAPER 86-2030] p 810 A86-47511

N

NACELLES

Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767

Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack p 770 A86-48825

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies [AD-A167356] p 807 N86-31570

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary [AD-A167443] p 807 N86-31571

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants [AD-A167444] p 807 N86-31572

NAP-OF-THE-EARTH NAVIGATION
Rotary-wing aircraft terrain-following/terrain-avoidance system development [AIAA PAPER 86-2147] p 823 A86-47456

Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783

A study of the rotor wake in nap-of-the-earth p 767 A86-48653

NASA PROGRAMS
NASA B737 flight test results of the Total Energy Control System [AIAA PAPER 86-2143] p 826 A86-47516

NASA's aircraft icing analysis program p 786 A86-49107

Topics in landing gear dynamics research at NASA Langley p 803 A86-49120

Laminar flow research applicable to subsonic aircraft p 781 A86-50269

NASA's Aircraft Icing Analysis Program [NASA-TM-88791] p 786 N86-31548

NAVIER-STOKES EQUATION
A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers p 847 A86-48647

- PN/S calculations for a fighter W/F at high-lift yaw conditions — parabolized Navier-Stokes computer code [AIAA PAPER 86-1829] p 779 A86-49588
- Navier-Stokes simulation of transonic flow over wing-fuselage combinations [AIAA PAPER 86-1831] p 779 A86-49589
- Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258
- Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392
- NAVIGATION AIDS**
- Effect of head-up display dynamics on fighter flying qualities [AIAA PAPER 86-2206] p 792 A86-47485
- Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations [NASA-TM-86779] p 789 N86-31551
- NAVY**
- Thermal stability concerns of Navy aviation fuel [ASME PAPER 86-GT-94] p 842 A86-48159
- NETWORK SYNTHESIS**
- Frequency and time domain designs of a strapdown vertical determination system [AIAA PAPER 86-2148] p 810 A86-47457
- NIGHT VISION**
- Applications of thermal imager devices incl. modelling aspects [MBB-UD-462-85-OE] p 850 A86-50254
- NITROGEN OXIDES**
- Premixing gas and air to reduce NOx emissions with existing proven gas turbine combustion chambers [ASME PAPER 86-GT-157] p 814 A86-48211
- A study on NOx emissions from gas turbine combustor [ASME PAPER 86-GT-168] p 814 A86-48220
- NOISE GENERATORS**
- Use of acoustic intensity measurements in the characterization of jet noise sources p 855 A86-48740
- Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems [AD-A167400] p 856 N86-32249
- NOISE MEASUREMENT**
- Measurements and computer modelling of engine exhaust noise in the cabin of single-engine aircraft p 798 A86-48594
- Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA [ONERA-RT-19/3463-AYP] p 841 N86-32451
- A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340 — propeller-driven aircraft [FFA-TN-1986-22] p 856 N86-33125
- NOISE PREDICTION**
- An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806
- NOISE PREDICTION (AIRCRAFT)**
- Area equivalent method (AEM) on VISICALC and LOTUS 1-2-3 - The Federal Aviation Administration's spreadsheet programs for predicting noise exposure contour areas around an airport p 853 A86-48595
- Broadband noise of propellers and rotors p 855 A86-48596
- Modelling of acoustic radiation problems associated with turbomachinery and rotating blades p 855 A86-48597
- Method for determining the ISO-noise levels by simulated aircraft flight operations p 856 A86-49099
- Prediction of single-rotation prop-fan noise by a frequency domain scheme [ONERA, TP NO. 1986-100] p 818 A86-49125
- Truncated Taylor series solutions to a generalized Burgers' equation p 856 A86-49716
- NOISE REDUCTION**
- Analysis and simulation of the MLS landing signal - Echo separation — French thesis p 788 A86-48564
- The aerodynamic potential of anti-sound p 855 A86-48977
- Control of interior noise in advanced turbopropeller aircraft p 802 A86-49100
- Active noise control — in prop-fan aircraft cabins p 803 A86-49101
- Noise control characteristics of synchrophasing. II - Experimental investigation — on aircraft fuselage model p 805 A86-49808
- Airport noise control strategies [AD-A167977] p 840 N86-31602
- On the way to extended noise reductions in propeller aircraft [B8573697] p 857 N86-33126

NOISE SPECTRA

- Measurements and computer modelling of engine exhaust noise in the cabin of single-engine aircraft p 798 A86-48594

NONDESTRUCTIVE TESTS

- Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing p 845 A86-47613
- Evaluation of damage tolerance requirements using a probabilistic-based life approach [ASME PAPER 86-GT-266] p 847 A86-48288
- Fibre optic damage detection in composite structures p 848 A86-48968

NONEQUILIBRIUM FLOW

- Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783

NONLINEAR PROGRAMMING

- Direct trajectory optimization using nonlinear programming and collocation [AIAA PAPER 86-2000] p 841 A86-47902

NONLINEAR SYSTEMS

- MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation — for F-14 flight simulation [AIAA PAPER 86-2085] p 853 A86-47505
- Design of a nonlinear lever-type mechanism for aircraft control systems p 835 A86-49139
- On control concept for in-flight simulation including actuator nonlinearities and time delays [ESA-TT-948] p 836 N86-31593

NOSES (FOREBODIES)

- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AD-A167717] p 781 N86-31539

NOTCH STRENGTH

- Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137

NOZZLE DESIGN

- The effect of a downstream rotor on the measured performance of a transonic turbine nozzle [ASME PAPER 86-GT-103] p 814 A86-48166

NOZZLE FLOW

- The effect of a downstream rotor on the measured performance of a transonic turbine nozzle [ASME PAPER 86-GT-103] p 814 A86-48166

NOZZLE GEOMETRY

- Passive control of jets with indeterminate origins p 780 A86-49807

NUMERICAL ANALYSIS

- Numerical analysis of aeroelastic stability problem of helicopter rotor blade p 798 A86-48662

NUMERICAL CONTROL

- Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control [AIAA PAPER 86-2017] p 826 A86-47652
- Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743
- Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659

NUMERICAL FLOW VISUALIZATION

- Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043

**OBLIQUE SHOCK WAVES**

- Intersection of an oblique shock wave with a cylindrical afterbody p 775 A86-49098

OBLIQUE WINGS

- Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft [AIAA PAPER 86-2243] p 824 A86-47491
- Model-following control for an oblique-wing aircraft [AIAA PAPER 86-2244] p 824 A86-47492

OBSERVABILITY (SYSTEMS)

- Single-state observer design considerations for aircraft application [AIAA PAPER 86-1996] p 852 A86-47418
- A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy [AIAA PAPER 86-2029] p 809 A86-47420

OBSTACLE AVOIDANCE

- Obstacle warning radar for helicopters - An anthropotechnical problem p 787 A86-47769

OCEAN SURFACE

- Evolution of the seawater activated release system (SEAWARS) — to prevent drownings after ejections from aircraft p 784 A86-47756

ONBOARD DATA PROCESSING

- Implications associated with the operation of digital data processing in the presence of the relatively harsh EMP environments produced by lightning p 809 A86-47319
- Optimization of onboard systems of data acquisition and processing — Russian book p 810 A86-48531

ONBOARD EQUIPMENT

- Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743

OPERATING COSTS

- Can future aircraft maintenance be afforded? p 857 A86-47617
- A review of unconventional aircraft design concepts p 801 A86-48995

OPTICAL COMMUNICATION

- Laser communication through low-visibility atmosphere for aircraft application p 788 A86-48581

OPTICAL EQUIPMENT

- Portable glide slope indicator [AD-D012240] p 789 N86-31552

OPTICAL TELESCOPES

- Low cost inertial reference system based on fiber gyros with GPS-aiding p 788 A86-49016

OPTICAL MEASUREMENT

- Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318

OPTICAL MEASURING INSTRUMENTS

- Optical detection methods for testing of fuel tank lightning ignition hazards p 791 A86-47309

OPTIMAL CONTROL

- Optimization and acceleration guidance of flight trajectories in a windshear [AIAA PAPER 86-2036] p 822 A86-47425
- Automated pole placement algorithm for multivariable optimal control synthesis [AIAA PAPER 86-2196] p 852 A86-47476
- A preliminary investigation of H (infinity) optimization [AIAA PAPER 86-2197] p 853 A86-47477
- Optimal descending, hypersonic turn to heading [AIAA PAPER 86-2134] p 841 A86-47679
- Optimal landing of a helicopter in autorotation [AIAA PAPER 86-2287] p 793 A86-47705
- Direct trajectory optimization using nonlinear programming and collocation [AIAA PAPER 86-2000] p 841 A86-47902
- An approach to an integrated control system for a modern fighter aircraft engine [ASME PAPER 86-GT-277] p 816 A86-48296
- The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation p 816 A86-48757
- Reducing fuel consumption by cyclic control p 832 A86-48991
- Near-optimal feedback control for three-dimensional interceptions p 854 A86-48982
- Optimal control laws for microburst encounter p 834 A86-49070

OPTIMIZATION

- Optimization of onboard systems of data acquisition and processing — Russian book p 810 A86-48531
- Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
- Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760
- Design of a supercritical airfoil p 771 A86-48982
- Automated structural optimisation at Warton — for aircraft p 854 A86-48987
- Optimum-Optimorum integrated wing-fuselage configuration for supersonic transport aircraft of second generation p 801 A86-49010
- The high lift development of the A320 aircraft p 772 A86-49012
- Maintainability optimization - The future challenge — for aircraft maintenance p 762 A86-49052
- On the optimization of flutter characteristics of laminated anisotropic cylindrical shells p 848 A86-49082
- Transonic wave drag estimation and optimization using the nonlinear area rule [AIAA PAPER 86-1798] p 778 A86-49582
- Optimization of composite structures by controlled insertion or deletion of diverse fiber types p 844 A86-50122
- Simulation and optimization techniques in computer aided design [NLR-MP-85022-U] p 854 N86-33053
- ORGANIZING**
- Design bureaux: The brain drainers. I - Toulouse - Aircraft mobilize a task force over 1700-strong p 763 A86-49464

OXYGEN SUPPLY EQUIPMENT

Scott emergency escape breathing device - Evaluation for use in Canadian forces aircraft p 784 A86-47731

P

P-3 AIRCRAFT

Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2 [ETN-86-97395] p 811 N86-31581

PAINTS

Stripping and painting a plane - Technological and economic aspects p 780 A86-47614

PANEL FLUTTER

Research on active suppression technology for wing/aileron flutter p 835 A86-49096

PANEL METHOD (FLUID DYNAMICS)

Unsteady low-speed aerodynamic model for complete aircraft configurations p 829 A86-47683

Application of the TranAir full-potential code to complete configurations p 772 A86-49009

Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044

Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method p 839 A86-49060

Oscillating wings and bodies with flexure in supersonic flow Applications of harmonic potential panel method p 776 A86-49108

Time-averaged subsonic propeller flowfield calculations [AIAA PAPER 86-1807] p 778 A86-49584

Aspect ratio effects on wings at low Reynolds numbers p 782 N86-32390

PANELS

The effect on the transmission loss of a double wall panel of using helium gas in the gap p 855 A86-48590

On the fast repair of aircraft panel components p 782 A86-49066

PARACHUTES

Evolution of the seawater activated release system (SEAWARS) - to prevent drownings after ejections from aircraft p 784 A86-47756

PARALLEL PROCESSING (COMPUTERS)

A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers p 847 A86-48647

PARAMETER IDENTIFICATION

Synthesis of an adaptive flight controller under unknown deterministic disturbances [AIAA PAPER 86-2157] p 823 A86-47464

Application of parameter estimation to highly unstable aircraft [AIAA PAPER 86-2020] p 827 A86-47655

Helicopter parameter identification technology research under the considerably disturbing condition p 831 A86-48670

Flight path reconstruction - A powerful tool for data compatibility check p 833 A86-49041

Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057

Identification of gust input and gust response characteristics from Do 28 TNT flight test data [ESA-TT-919] p 837 N86-32445

PARTIAL PRESSURE

Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels [ASME PAPER 86-GT-163] p 843 A86-48216

PARTICLE MOTION

Particulate flow solutions through centrifugal impeller with two splitters [ASME PAPER 86-GT-130] p 765 A86-48188

PASSENGER AIRCRAFT

Applications of computer-aided engineering to subsonic aircraft design in a university environment p 801 A86-48986

Potential application of advanced propulsion systems to civil aircraft p 802 A86-49093

Measurements of landing gear loads of a commuter airliner p 803 A86-49119

Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2 [NASA-CR-4014] p 836 N86-32440

A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340 - propeller-driven aircraft [FFA-TN-1986-22] p 856 N86-33125

PERFORATED PLATES

The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918

PERFORMANCE PREDICTION

Flight test evaluation of techniques to predict longitudinal pilot induced oscillations [AIAA PAPER 86-2253] p 826 A86-47509

A general computational method for simulation and prediction of transient behavior of gas turbines [ASME PAPER 86-GT-180] p 815 A86-48230

Performance evaluation of a linear recursive technique for aircraft altitude prediction in airborne collision avoidance systems p 811 A86-49085

Residual strength prediction for planked wing tension surfaces [AIAA PAPER 86-0941] p 849 A86-49572

PERFORMANCE TESTS

Operation of the CT7 turboprop engine as an auxiliary power unit (APU) [ASME PAPER 86-GT-28] p 812 A86-48119

Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563

PERTURBATION THEORY

Interior transition layers in flight path optimization [AIAA PAPER 86-2037] p 797 A86-48576

PHOTOGRAMMETRY

In-flight photogrammetric measurement of wing ice accretions [NASA-TM-87191] p 806 N86-31562

PILOT INDUCED OSCILLATION

Flight test evaluation of techniques to predict longitudinal pilot induced oscillations [AIAA PAPER 86-2253] p 826 A86-47509

PILOT PERFORMANCE

Pitch rate sensitivity criterion for category C flight phases - Class IV aircraft [AIAA PAPER 86-2201] p 823 A86-47481

Cooperative synthesis of control and display augmentation [AIAA PAPER 86-2204] p 853 A86-47484

Identification of pilot dynamics in a system with a choice of feedback structures [AIAA PAPER 86-2250] p 825 A86-47496

The interpretation of flying qualities requirements for flight control design [AIAA PAPER 86-2249] p 826 A86-47523

Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672

PILOT TRAINING

Pilot evaluation of experimental flight trajectories in the near-terminal area [AIAA PAPER 86-2074] p 838 A86-47664

PITCH (INCLINATION)

Pitch rate sensitivity criterion for category C flight phases - Class IV aircraft [AIAA PAPER 86-2201] p 823 A86-47481

Visualization of dynamic stall controlled by large amplitude interrupted pitching motions [AIAA PAPER 86-2281] p 764 A86-47699

PLASTIC AIRCRAFT STRUCTURES

Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331

Analysis of the costs and weight effects of CFK on air transport structure p 842 A86-48097

Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure p 785 A86-48989

The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001

Plastic or metal - The judgement factors - for selecting aircraft construction material p 762 A86-49037

Manufacturing technology of composite torque box of vertical fin p 848 A86-49068

A general formulation for the aeroelastic divergence of composite sweptforward wing structures p 802 A86-49095

Aeroelastic tailoring of aft-swept high aspect ratio composite wings p 802 A86-49097

Structural design and analysis aspects of composite helicopter components [MBB-UD-454-85-OE] p 806 A86-50256

PLATEAUS

Use and maintenance of helicopters on the plateau - areas of China p 785 A86-48669

PLUMES

Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust [AIAA PAPER 86-1809] p 778 A86-49585

POISSON EQUATION

Elliptic generation of composite three-dimensional grids about realistic aircraft [NASA-TM-88240] p 763 N86-31527

POLYMER MATRIX COMPOSITES

Advanced polymer composites for high temperature applications p 843 A86-49021

POROUS BOUNDARY LAYER CONTROL

The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174

PORTABLE EQUIPMENT

Portable glide slope indicator [AD-D012240] p 789 N86-31552

POSITION (LOCATION)

Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299

POTENTIAL ENERGY

The application of energy techniques to propeller-driven airplanes [AD-A167113] p 807 N86-31569

POTENTIAL FLOW

Potential flow models of airfoils with separated flow p 772 A86-49013

An entropy correction method for unsteady full potential flows with strong shocks [AIAA PAPER 86-1768] p 777 A86-49576

Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches [AIAA PAPER 86-1821] p 778 A86-49586

Computation of the potential flow over airfoils with cusped or thin trailing edges p 780 A86-49823

POTENTIAL THEORY

Application of a full potential method to practical problems in supersonic aircraft design and analysis p 773 A86-49030

Applications of potential theory computations to transonic aeroelasticity p 775 A86-49105

Validation of a full potential method for combined yaw and angle of attack [AIAA PAPER 86-1834] p 779 A86-49591

POWER SPECTRA

The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques - aircraft design [NLR-TR-85014-U] p 809 N86-32430

POWERED LIFT AIRCRAFT

Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676

PREDICTION ANALYSIS TECHNIQUES

Broadband noise of propellers and rotors p 855 A86-48596

Prediction of gust loadings and alleviation at transonic speeds [AIAA PAPER 86-0997] p 777 A86-49573

An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 763 N86-31529

PREMIXED FLAMES

Premixing gas and air to reduce NO_x emissions with existing proven gas turbine combustion chambers [ASME PAPER 86-GT-157] p 814 A86-48211

PRESSURE DISTRIBUTION

Method for calculating pressure distribution on the surfaces of wings with slat mechanization p 768 A86-48806

Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044

Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046

PRESSURE MEASUREMENT

Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator [AIAA PAPER 86-2026] p 827 A86-47660

The use of surface static pressure data as a diagnostic tool in multistage compressor development [ASME PAPER 86-GT-3] p 812 A86-48103

Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results - German thesis p 767 A86-48568

PRESSURE SENSORS

Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer p 775 A86-49074

Practical applications of Tesla semiconductor pressure sensors p 849 A86-49148

PROBABILITY DISTRIBUTION FUNCTIONS

Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49607

PROBABILITY THEORY

Evaluation of damage tolerance requirements using a probabilistic-based life approach [ASME PAPER 86-GT-266] p 847 A86-48288

An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 763 N86-31529

PRODUCT DEVELOPMENT

Developments in new gas turbine engine demonstrator programs [ASME PAPER 86-GT-80] p 813 A86-48148

Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program [NLR-MP-84023-U] p 811 N86-32431

Recent developments in propulsion aerodynamics
[NLR-MP-85031-U] p 820 A86-32437

PRODUCTION ENGINEERING
Fabrication of high-alumina ceramic fixtures for jet engine repair applications
[ASME PAPER 86-GT-46] p 846 A86-48130

PRODUCTION MANAGEMENT
The competitive and cooperative outlook for aircraft propulsion systems
[AIAA PAPER 86-1134] p 857 A86-49571

PRODUCTIVITY
Airbus-assembly concepts to improve productivity and flexibility in aircraft construction
p 761 A86-48999

PROJECTILES
Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660
Parametric study of low Reynolds number processing/spinning incompressible flows — applicable to flight stability of liquid-filled projectiles
[AIAA PAPER 86-2027] p 827 A86-47661

PROP-FAN TECHNOLOGY
A propfan status report p 817 A86-49091
Propfan and turbofan - Antagonism or synthesis
p 817 A86-49092
Potential application of advanced propulsion systems to civil aircraft
p 802 A86-49083
Prediction of single-rotation prop-fan noise by a frequency domain scheme
[ONERA, TP NO. 1986-100] p 818 A86-49125
System design and integration of the large-scale advanced prop-fan
[NASA-CR-174789] p 781 A86-31536

PROPELLANT ADDITIVES
The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49983

PROPELLER BLADES
Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller
[AIAA PAPER 86-1893] p 780 A86-49625

PROPELLER DRIVE
Active noise control — in prop-fan aircraft cabins
p 803 A86-49101

PROPELLER EFFICIENCY
Wind influence on the range of jet or propeller aircraft
p 801 A86-48990
New technology propulsion (ANT) for general aviation aircraft, phase I
[BMFT-FB-W-85-031] p 820 A86-31589

PROPELLER FANS
On the way to extended noise reductions in propeller aircraft
[B8573697] p 857 A86-33126

PROPELLER SLIPSTREAMS
Wing laminar boundary layer in the presence of a propeller slipstream p 776 A86-49122

PROPELLERS
Quantifying a propeller/engine power response rate mismatch p 796 A86-47801
Broadband noise of propellers and rotors
p 855 A86-48596
Modelling of acoustic radiation problems associated with turbomachinery and rotating blades p 855 A86-48597
Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow
[AIAA PAPER 86-0467] p 856 A86-49566
Time-averaged subsonic propeller flowfield calculations
[AIAA PAPER 86-1807] p 778 A86-49584
The application of energy techniques to propeller-driven airplanes
[AD-A167113] p 807 A86-31569
Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA
[ONERA-RT-19/3463-AYP] p 841 A86-32451

PROPULSION SYSTEM CONFIGURATIONS
Heat management in advanced aircraft gas turbine engines
[ASME PAPER 86-GT-76] p 813 A86-48144
The competitive and cooperative outlook for aircraft propulsion systems
[AIAA PAPER 86-1134] p 857 A86-49571
New technology propulsion (ANT) for general aviation aircraft, phase I
[BMFT-FB-W-85-031] p 820 A86-31589
Recent developments in propulsion aerodynamics
[NLR-MP-85031-U] p 820 A86-32437

PROPULSION SYSTEM PERFORMANCE
Aeropropulsion opportunities for the 21st century
[NASA-TM-88817] p 819 A86-31585

PUSHPUS EFFICIENCY
Quantifying a propeller/engine power response rate mismatch p 796 A86-47801

Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
Aeropropulsion opportunities for the 21st century
[NASA-TM-88817] p 819 A86-31585

PROTECTIVE COATINGS
Coatings — for Al alloy corrosion control
p 845 A86-47721

PULSE GENERATORS
Design of a fast risetime lightning generator
p 837 A86-47304
Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system
p 790 A86-47305

PUMPS
Pumps for 8000 psi hydraulic systems examined
p 846 A86-48042

PYLONS
Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767
Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 A86-31568

Q

QUADRATIC EQUATIONS
Automated pole placement algorithm for multivariable optimal control synthesis
[AIAA PAPER 86-2196] p 852 A86-47476

QUALITY CONTROL
Chemical analysis for control — of Al alloy aircraft structures p 842 A86-47720
Quality assurance in the reconditioning of gas turbine and compressor blading components
[ASME PAPER 86-GT-299] p 847 A86-48311
An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography p 844 A86-49984

R

RADAR APPROACH CONTROL
Airborne intruder detection considerations
[DE86-006462] p 808 A86-31576
Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system
[NPL-VG-84-009-L] p 789 A86-32419

RADAR DETECTION
Obstacle warning radar for helicopters - An anthropotechnical problem p 787 A86-47769

RADAR IMAGERY
Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system
[NPL-VG-84-009-L] p 789 A86-32419

RADAR NAVIGATION
Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783

RADAR TRACKING
Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system
[NPL-VG-84-009-L] p 789 A86-32419

RADIO ECHOES
Analysis and simulation of the MLS landing signal - Echo separation — French thesis p 788 A86-48564

RADOMES
Aspects of lightning protection schemes for radomes
p 792 A86-47338

RAMJET ENGINES
Theoretical considerations of the specific impulse of ramjet engines p 817 A86-49111
A comparison of pod and tail mounted ramjets
p 818 A86-49112
Regression rate study for a solid fuel ramjet
p 818 A86-49113

RATIOS
Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507

REAL TIME OPERATION
Rotary-wing aircraft terrain-following/terrain-avoidance system development
[AIAA PAPER 86-2147] p 823 A86-47456
An artificial intelligence approach to onboard fault monitoring and diagnosis for aircraft applications
[AIAA PAPER 86-2093] p 853 A86-48577

REATTACHED FLOW
Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031

RECEIVERS
Loran C 1984 spring-summer stability
[AD-A167867] p 789 A86-31555

RECTANGULAR PLATES
Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading
p 848 A86-49040

The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918

REDUCED ORDER FILTERS
Frequency and time domain designs of a strapdown vertical determination system
[AIAA PAPER 86-2148] p 810 A86-47457

REELS
Evaluation of a pre-ejection upper torso retraction device p 793 A86-47728
Advancements in inertia reels for fixed seating aircraft
p 784 A86-47744

REENTRY GUIDANCE
Optimal descending, hypersonic turn to heading
[AIAA PAPER 86-2134] p 841 A86-47679

REFRACTIVITY
Loran C 1984 spring-summer stability
[AD-A167867] p 789 A86-31555

REFRACTORY MATERIALS
Materials in aerospace - Can the emerging thermoplastics meet the challenge? p 843 A86-49020

REFUELING
Live tests on static electricity in fuelling of aircraft
p 783 A86-47334

REGENERATORS
An overview of the Small Engine Component Technology (SECT) studies
[NASA-TM-88796] p 819 A86-31587

REGRESSION COEFFICIENTS
Regression rate study for a solid fuel ramjet
p 818 A86-49113

REGULATIONS
A proposed plane for the initial flight testing of a Rutan Aircraft Factory long-EZ and other light amateur experimental aircraft p 794 A86-47777

REINFORCED SHELLS
Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load
p 849 A86-49128

REINFORCING FIBERS
Optimization of composite structures by controlled insertion or deletion of diverse fiber types
p 844 A86-50122

RELIABILITY ANALYSIS
Engine control reliability and durability improvement through accelerated mission environmental testing
[ASME PAPER 86-GT-52] p 813 A86-48132
Some aspects of the reliability analysis of aircraft structures p 849 A86-49127
Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear — Russian book p 804 A86-49288

RELIABILITY ENGINEERING
Engine component life prediction methodology for conceptual design investigations
[ASME PAPER 86-GT-24] p 812 A86-48116
The airline engineering role in the management of safety p 782 A86-49084
Short cracks in aerospace structures
[NLR-MP-85054-U] p 851 A86-32781

REMODEL PILOTED VEHICLES
Flight test experience and controlled impact of a large, four-engine remotely piloted airplane
p 794 A86-47781
Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model
p 796 A86-47800
A comparison of pod and tail mounted ramjets
p 818 A86-49112
Design of a vertical thrust stand for a remotely piloted model helicopter
[AD-A167811] p 840 A86-31598

RESEARCH AIRCRAFT
User's manual for the Falcon system — Falcon research aircraft
[ESA-TT-936] p 808 A86-31579

RESEARCH AND DEVELOPMENT
Stratified charge rotary engine for general aviation
[ASME PAPER 86-GT-181] p 815 A86-48231
The helicopter technology of China
p 761 A86-48652
The high lift development of the A320 aircraft
p 772 A86-49012
Certification of advanced experimental aircraft
p 785 A86-49036
Topics in landing gear dynamics research at NASA Langley
p 803 A86-49120
Design bureaus: The brain drainers. I - Toulouse - Aircraft mobilize a task force over 1700-strong
p 763 A86-49464
Modern developments in rotorcraft technology
[MBB-UD-458-85-OE] p 805 A86-49509

RESIDUAL STRENGTH
Residual strength prediction for planked wing tension surfaces
[AIAA PAPER 86-0941] p 849 A86-49572

RESIDUAL STRESS

The control and use of residual stresses in aircraft structural parts p 849 A86-49114

RESONANT VIBRATION

Solid-beam model of a deformable aircraft for natural-vibration studies p 804 A86-49444

The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918

RETRACTABLE EQUIPMENT

New design procedures applied to landing gear development p 803 A86-49117

REVERSED FLOW

The performance of a reverse flow combustor using JP 10 fuel [ASME PAPER 86-GT-148] p 814 A86-48202

REVISIONS

Development of the BO 105 LS [MBB-UD-456-85-OE] p 805 A86-50255

RIDING QUALITY

Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2 [NASA-CR-4014] p 836 N86-32440

RIGID ROTORS

A study of stability and control of a hingeless rotor helicopter with non-uniform induced velocity field p 831 A86-48655

Dynamic aspects in the design of advanced rotor systems p 798 A86-48663

RIGID STRUCTURES

Modelling of rigid-body and elastic aircraft dynamics for flight control development [AIAA PAPER 86-2232] p 829 A86-47693

ROBOTICS

Case studies in aircraft manufacturing automation p 762 A86-49000

ROBOTS

Robotic systems concepts for the rapid turnaround of tactical aircraft in a biochemical environment p 761 A86-47763

ROBUSTNESS (MATHEMATICS)

Synthesis of an adaptive flight controller under unknown deterministic disturbances [AIAA PAPER 86-2157] p 823 A86-47464

Performance characteristics of an adaptive controller based on least-mean-square filters [AIAA PAPER 86-2160] p 852 A86-47466

A design methodology for robust stabilizing controllers [AIAA PAPER 86-2195] p 823 A86-47475

A controller for robust asymptotic tracking in systems with time-varying uncertainties [AIAA PAPER 86-2199] p 853 A86-47479

Application of eigenstructure assignment to design of robust decoupling controllers in MIMO systems --- for helicopters [AIAA PAPER 86-2246] p 825 A86-47493

A robust adaptive flightpath reconstruction technique [AIAA PAPER 80-2018] p 826 A86-47653

ROTARY ENGINES

Stratified charge rotary engine for general aviation [ASME PAPER 86-GT-181] p 815 A86-48231

ROTARY WING AIRCRAFT

Rotary-wing aircraft terrain-following/terrain-avoidance system development [AIAA PAPER 86-2147] p 823 A86-47456

A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP [AD-A167719] p 808 N86-31575

ROTARY WINGS

A study of the rotor wake in nap-of-the-earth p 767 A86-48653

Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659

The physical understanding on helicopter air and ground resonance p 798 A86-48660

Numerical analysis of aeroelastic stability problem of helicopter rotor blade p 798 A86-48662

Dynamic aspects in the design of advanced rotor systems p 798 A86-48663

Rotor aeroelastic stability p 798 A86-48664

Rotor-fuselage dynamic coupling characteristics of helicopter air and ground resonance p 799 A86-48666

Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis p 799 A86-48667

Oscillation equations for a helicopter rotor blade p 800 A86-48805

A study of helicopter main rotor noise in hover [AIAA PAPER 86-1858] p 856 A86-49575

Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580

Vortex influence on oscillating airfoil at high angle-of-attack [AIAA PAPER 86-1837] p 779 A86-49592

Recent developments in rotary-wing aerodynamic theory p 780 A86-49802

Fatigue resistance of high quality steels under multiaxial load [ETN-86-97878] p 851 N86-32785

ROTATING DISKS

Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbopfan [ASME PAPER 86-GT-98] p 813 A86-48163

ROTATING SHAFTS

Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbopfan [ASME PAPER 86-GT-98] p 813 A86-48163

ROTOR AERODYNAMICS

The physical understanding on helicopter air and ground resonance p 798 A86-48660

Numerical analysis of aeroelastic stability problem of helicopter rotor blade p 798 A86-48662

Rotor aeroelastic stability p 798 A86-48664

Nonlinear dynamics or rotor/blade/casing rub interactions [ASME PAPER 86-DE-6] p 818 A86-49620

Recent developments in rotary-wing aerodynamic theory p 780 A86-49802

A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425

ROTOR BLADES

Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580

ROTOR BLADES (TURBOMACHINERY)

Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage [ASME PAPER 86-GT-56] p 785 A86-48134

Splitter blades as an aeroelastic detuning mechanism for unstalled supersonic flutter of turbomachine rotors [ASME PAPER 86-GT-99] p 813 A86-48164

ROTOR BODY INTERACTIONS

Coupled aeroelastic hub loads reduction p 799 A86-48665

Rotor-fuselage dynamic coupling characteristics of helicopter air and ground resonance p 799 A86-48666

Nonlinear dynamics or rotor/blade/casing rub interactions [ASME PAPER 86-DE-6] p 818 A86-49620

ROTOR SPEED

Evaluation of the blade-to-blade flow from a high speed compressor rotor [ASME PAPER 86-GT-117] p 765 A86-48176

ROTORCRAFT AIRCRAFT

Modern developments in rotorcraft technology [MBB-UD-458-85-OE] p 805 A86-49509

ROTORS

The effect of a downstream rotor on the measured performance of a transonic turbine nozzle [ASME PAPER 86-GT-103] p 814 A86-48166

Broadband noise of propellers and rotors p 855 A86-48596

RUDDERS

Identification of unsteady response in rudders at low velocities [AAAF PAPER NT 85-19] p 797 A86-48468

S**S-N DIAGRAMS**

Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137

Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve p 804 A86-49138

S-61 HELICOPTER

Retrofit energy-absorbing crewseat for the SH-3 (S-61 series) Sea King helicopter p 793 A86-47736

SAAB AIRCRAFT

A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340 --- propeller-driven aircraft [FFA-TN-1986-22] p 856 N86-33125

SAFETY MANAGEMENT

Airports build for future traffic amid new security concern p 838 A86-48371

Managing airworthiness p 785 A86-49035

The airline engineering role in the management of safety p 762 A86-49084

SCALE MODELS

A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054

SCATTERING COEFFICIENTS

Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve p 804 A86-49138

SCENE ANALYSIS

Simulator scene display evaluation device [NASA-CASE-ARC-11504-1] p 840 N86-32447

SCREEN EFFECT

An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen p 770 A86-48841

SCRUBBERS

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests [AD-A167445] p 807 N86-31573

SEATS

Retrofit energy-absorbing crewseat for the SH-3 (S-61 series) Sea King helicopter p 793 A86-47736

Advancements in inertia reels for fixed seating aircraft p 784 A86-47744

SECONDARY FLOW

Predictions of endwall losses and secondary flows in axial flow turbine cascades [ASME PAPER 86-GT-228] p 766 A86-48262

SECONDARY RADAR

Secondary radar leads - Monopulse points the way p 787 A86-48372

SECURITY

Airborne intruder detection considerations [DE86-006482] p 808 N86-31576

SELF OSCILLATION

Self-oscillatory regimes of aircraft motion during spin-roll coupling p 832 A86-48775

A certain type of self-oscillation of aircraft landing-gear wheels p 800 A86-48829

Solid-beam model of a deformable aircraft for natural-vibration studies p 804 A86-49444

SEMICONDUCTOR DEVICES

Practical applications of Tesla semiconductor pressure sensors p 849 A86-49148

SEMICONDUCTOR LASERS

Laser communication through low-visibility atmosphere for aircraft application p 788 A86-48581

SENSORS

Sensor selection for the Boeing CREST ejection seat design p 793 A86-47757

Smart probes for air data p 811 A86-49498

SEPARATED FLOW

Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 788 A86-48779

Determination of the aerodynamic characteristics of separated flow past a wing with allowance for slight unsteadiness induced by changes in angle of attack p 769 A86-48816

Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme p 769 A86-48822

Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838

Flow of an ideal fluid in the core of a vortex sheet p 770 A86-48839

A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842

Potential flow models of airfoils with separated flow p 772 A86-49013

Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031

Computations of separated subsonic and transonic flow about airfoils in unsteady motion [NLR-MP-84094-U] p 782 N86-31541

SEQUENCING

Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743

SERVICE LIFE

Engine component life prediction methodology for conceptual design investigations [ASME PAPER 86-GT-24] p 812 A86-48116

Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve p 804 A86-49138

Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear --- Russian book p 804 A86-49288

Cost reductions from introduction of new life philosophies for aircraft engine discs [NLR-MP-85076-U] p 820 N86-32438

SERVOCONTROL

An approach to integrated aeroservoelastic tailoring for stability p 836 N86-32439

Servo-actuator for sampled-data feedback disturbance rejection --- helicopters [DFVLR-FB-86-08] p 837 N86-32446

SH-3 HELICOPTER

A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425

Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580

- SHAPES**
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48848
- SHEAR STRESS**
Studies for the application of a flexible weight and balance (W/B) measuring facility for commercial aircraft [BMFT-FB-W-85-029] p 840 N86-31804
- SHOCK WAVES**
An entropy correction method for unsteady full potential flows with strong shocks [AIAA PAPER 86-1788] p 777 A86-49576
- SHORT HAUL AIRCRAFT**
Measurements of landing gear loads of a commuter airliner p 803 A86-49119
- SHORT TAKEOFF AIRCRAFT**
Robust fault detection and isolation for a high performance aircraft on STOL approach [AIAA PAPER 86-2031] p 821 A86-47421
Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676
The ground effects of a powered-lift STOL aircraft during landing approach p 795 A86-47784
A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP [AD-A167719] p 808 N86-31575
- SIDESLIP**
Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip [NASA-TM-87722] p 781 N86-31532
- SIGNAL ANALYSIS**
Analysis and simulation of the MLS landing signal - Echo separation --- French thesis p 788 A86-48564
- SIGNAL PROCESSING**
Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems [AD-A167400] p 856 N86-32249
- SIGNAL TO NOISE RATIOS**
Loran C 1984 spring-summer stability [AD-A167867] p 789 N86-31555
- SIMILITUDE LAW**
Similarity criteria for a circulation control airfoil p 769 A86-48815
- SIMULATION**
Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 N86-31590
- SIMULATORS**
Ground based helicopter simulation p 838 A86-48673
- SINGLE CRYSTALS**
Single crystal superalloys for turbine blades in advanced aircraft engines [ONERA, TP NO. 1986-102] p 843 A86-49077
- SKIN (STRUCTURAL MEMBER)**
Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection p 845 A86-47329
- SLENDER BODIES**
Transonic wave drag estimation and optimization using the nonlinear area rule [AIAA PAPER 86-1798] p 778 A86-49582
- SLENDER WINGS**
Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845
Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049
Aeroelastic tailoring of aft-swept high aspect ratio composite wings p 802 A86-49097
- SLOTTED WIND TUNNELS**
Numerical design parameter study for slotted walls in transonic wind tunnels p 839 A86-49059
- SOFTWARE ENGINEERING**
Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042
- SOFTWARE TOOLS**
MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation --- for F-14 flight simulation [AIAA PAPER 86-2085] p 853 A86-47505
- SOLID PROPELLANTS**
Regression rate study for a solid fuel ramjet p 818 A86-49113
- SOUND FIELDS**
An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow [AIAA PAPER 86-0467] p 856 A86-49566
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806
- SOUND GENERATORS**
Sounding a happy note for lift --- sound generation to prevent stalling p 780 A86-49676
- SOUND INTENSITY**
Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738
Use of acoustic intensity measurements in the characterization of jet noise sources p 855 A86-48740
- SOUND PRESSURE**
Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738
- SOUND WAVES**
Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems [AD-A167400] p 856 N86-32249
- SPACECRAFT CONSTRUCTION MATERIALS**
Materials in aerospace - Can the emerging thermoplastics meet the challenge? p 843 A86-49020
Advanced polymer composites for high temperature applications p 843 A86-49021
- SPACECRAFT CONTROL**
Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers p 852 A86-47401
- SPACECRAFT DESIGN**
Integrated structure/control design - Present methodology and future opportunities p 854 A86-49084
- SPACERS**
Low mass diffusion bonding tools [AD-D012295] p 851 N86-32746
- SPANWISE BLOWING**
Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046
- SPARK IGNITION**
Optical detection methods for testing of fuel tank lightning ignition hazards p 791 A86-47309
- SPATIAL MARCHING**
Validation of a full potential method for combined yaw and angle of attack [AIAA PAPER 86-1834] p 779 A86-49591
- SPECIFIC IMPULSE**
Theoretical considerations of the specific impulse of ramjet engines p 817 A86-49111
- SPLIT FLAPS**
Potential flow models of airfoils with separated flow p 772 A86-49013
- SPOILERS**
Potential flow models of airfoils with separated flow p 772 A86-49013
Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows [ONERA, TP NO. 1986-101] p 776 A86-49106
- SPRAY NOZZLES**
Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels [NASA-TM-87316] p 820 N86-31588
- STABILIZERS**
Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer [ASME PAPER 86-GT-174] p 815 A86-48225
- STABILIZERS (FLUID DYNAMICS)**
Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331
Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials p 762 A86-49067
- STAGNATION FLOW**
Flow stagnation as an advanced windblast protection technique --- for ejection seat safety p 793 A86-47727
- STAINLESS STEELS**
Low mass diffusion bonding tools [AD-D012295] p 851 N86-32746
- STANDARDS**
TURBISTAN: A standard load sequence for aircraft engine disks [NLR-MP-85033-U] p 820 N86-32436
- STATIC ELECTRICITY**
International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings p 844 A86-47292
Live tests on static electricity in fuelling of aircraft p 783 A86-47334
- STATIC PRESSURE**
The use of surface static pressure data as a diagnostic tool in multistage compressor development [ASME PAPER 86-GT-3] p 812 A86-48103
- STATIC STABILITY**
Limitations of statically unstable aircraft due to the effects of sensor noise, turbulence, and structural dynamics [AIAA PAPER 86-2203] p 824 A86-47483
Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control p 833 A86-49039
- STATISTICAL ANALYSIS**
Determination of the statistical characteristics of aircraft motion during an automatic approach p 832 A86-48844
Investigations in landing process of aircraft by means of the Monte-Carlo method [ESA-TT-951] p 808 N86-31578
- STATISTICAL DISTRIBUTIONS**
An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 763 N86-31529
- STATISTICAL TESTS**
Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507
- STEEL STRUCTURES**
Fatigue fracture in landing gear steels p 803 A86-49115
- STEELS**
Fatigue resistance of high quality steels under multiaxial load [ETN-86-97878] p 851 N86-32785
- STIFFENING**
Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners) [SNIAS-436.021/85] p 851 N86-32784
- STIFFNESS**
Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845
The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918
- STOCHASTIC PROCESSES**
A stochastic decentralized flight control system [AIAA PAPER 86-1994] p 821 A86-47416
- STORMS (METEOROLOGY)**
Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299
- STRAIN GAGES**
Measurements of landing gear loads of a commuter airliner p 803 A86-49119
Strain-gauge autopilot altitude corrector p 811 A86-49142
Application of strain gauge amplifiers and computer technology to the strength testing of aircraft p 849 A86-49144
Application of strain gauge methods to determination of in-flight loads of structure groups of small transport aircraft p 811 A86-49149
Aspect ratio effects on wings at low Reynolds numbers p 782 N86-32390
- STRAKES**
Use of hinged strakes for lateral control at high angles of attack [AIAA PAPER 86-2278] p 830 A86-47696
Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049
- STRAPDOWN INERTIAL GUIDANCE**
Frequency and time domain designs of a strapdown vertical determination system [AIAA PAPER 86-2148] p 810 A86-47457
- STRATEGY**
Airport noise control strategies [AD-A167977] p 840 N86-31602
- STREAM FUNCTIONS (FLUIDS)**
Numerical solution of transonic stream function equation on S1 stream surface in cascade [ASME PAPER 86-GT-110] p 765 A86-48172
A method for transonic inverse cascade design with a stream function equation [ASME PAPER 86-GT-189] p 766 A86-48239
- STRESS ANALYSIS**
Computing codes for development of helicopter crashworthy structures and test substantiation p 798 A86-48657
Calculation of the loading of the airframe in flight due to multidimensional turbulence p 799 A86-48759
Experience with stress analysis during airframe fatigue tests p 840 A86-49143
Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear --- Russian book p 804 A86-49288
- STRESS CONCENTRATION**
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48846

STRESS INTENSITY FACTORS

- Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners)
[SNIAS-436.021/85] p 851 N86-32784

STRIPPING

- Stripping and painting a plane - Technological and economic aspects p 780 A86-47614

STRUCTURAL ANALYSIS

- Structural analysis of adhesive-bonded joints p 846 A86-47722
- Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141
- Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
- Unified constitutive materials model development and evaluation for high-temperature structural analysis applications — for aircraft gas turbine engines p 849 A86-49133
- Structural design and analysis aspects of composite helicopter components
[MBB-UD-454-85-OE] p 806 A86-50256

STRUCTURAL DESIGN

- Influence of EFCS-control laws on structural design of modern transport aircraft p 800 A86-48984
- Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- Structural design and analysis aspects of composite helicopter components
[MBB-UD-454-85-OE] p 806 A86-50256

STRUCTURAL DESIGN CRITERIA

- Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141
- Optimum design technique for rotating wheels
[ASME PAPER 86-GT-255] p 846 A86-48281
- Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776
- New design procedures applied to landing gear development p 803 A86-49117
- The development of aeroelastic tailoring in the United States p 805 A86-50111
- Advisory Circular: Design considerations to protect fuel systems during a wheels-up landing
[FAA-AC/25.994-1] p 806 N86-31564
- The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques — aircraft design
[NLR-TR-85014-U] p 809 N86-32430
- Fatigue resistance of high quality steels under multiaxial load
[ETN-86-97878] p 851 N86-32785

STRUCTURAL FAILURE

- A theory for fault-tolerant flight control combining expert system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442
- The control and use of residual stresses in aircraft structural parts p 849 A86-49114
- Fatigue fracture in landing gear steels p 803 A86-49115

STRUCTURAL RELIABILITY

- Supplemental inspections of aging aircraft p 845 A86-47525
- Ageing aircraft as seen by an authority p 783 A86-47611
- Durability and damage tolerance assessment of the TF34-100 engine
[ASME PAPER 86-GT-38] p 812 A86-48125
- A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054
- Some aspects of the reliability analysis of aircraft structures p 849 A86-49127

STRUCTURAL STABILITY

- Aeroelastic behavior of low aspect ratio metal and composite blades
[ASME PAPER 86-GT-243] p 846 A86-48271
- Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading p 848 A86-49040

STRUCTURAL VIBRATION

- Coupled aeroelastic hub loads reduction p 799 A86-48665
- Shimmy problems of landing gears caused by elastic deformation of tires p 803 A86-49118
- Dynamic analysis: Correlation of theory with experiment — MSC/NASTRAN analysis of Westland 30 G-BGHE [RP661] p 851 N86-31917

STRUCTURAL WEIGHT

- Analysis of the costs and weight effects of CFK on air transport structure p 842 A86-48097
- Automated structural optimisation at Warton — for aircraft p 854 A86-48987

SUBSONIC AIRCRAFT

- Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767
- Applications of computer-aided engineering to subsonic aircraft design in a university environment p 801 A86-48986
- Method of analysing data on a swept wing aircraft in flight p 775 A86-48103
- Laminar flow research applicable to subsonic aircraft p 781 A86-50269

SUBSONIC FLOW

- Subsonic/transonic stall flutter investigation of an advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
- A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method
[ASME PAPER 86-GT-111] p 765 A86-48173
- Method for calculating subsonic ideal-gas flow past an aircraft p 788 A86-48807
- Method for the visualization of subsonic gas flows p 769 A86-48808
- Time-averaged subsonic propeller flowfield calculations
[AIAA PAPER 86-1807] p 778 A86-49584
- Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- Computations of separated subsonic and transonic flow about airfoils in unsteady motion
[NLR-MP-84094-U] p 782 N86-31541

SUBSONIC SPEED

- Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027
- The application of energy techniques to propeller-driven airplanes
[AD-A187113] p 807 N86-31569

SUBSONIC WIND TUNNELS

- Reduction of turbulent drag - Turbulence manipulators
[AAAF PAPER NT 85-04] p 766 A86-48455
- The F2 wind tunnel of the Fauga-Mauzac Test Center
[ONERA, TP NO. 1986-104] p 839 A86-49075

SUCTION

- Trapping of a free vortex by airfoils with surface suction p 780 A86-49801

SUPERCritical AIRFOILS

- Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
- Design of a supercritical airfoil p 771 A86-48982
- Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer p 775 A86-49074
- Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows
[ONERA, TP NO. 1986-101] p 776 A86-49106

SUPERCritical FLOW

- Aerodynamic design methods for modern transport aircraft
[ESA-TT-923] p 782 N86-31543

SUPERCritical WINGS

- Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457
- Computations of separated subsonic and transonic flow about airfoils in unsteady motion
[NLR-MP-84094-U] p 782 N86-31541

SUPersonic AIRCRAFT

- Flight testing a transsonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782
- Optimum-Optimum integrated wing-fuselage configuration for supersonic transport aircraft of second generation p 801 A86-49010
- Application of a full potential method to practical problems in supersonic aircraft design and analysis p 773 A86-49030

SUPersonic DRAG

- Wave drag of a supersonic air intake at high subsonic velocities p 770 A86-48834

SUPersonic FLIGHT

- The drag of a pair of bodies at supersonic flight velocities p 768 A86-48802

SUPersonic FLOW

- Some aspects of supersonic flow over a cavity cascade
[AIAA PAPER 86-2025] p 764 A86-47659
- A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method
[ASME PAPER 86-GT-111] p 765 A86-48173

- Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results — German thesis p 767 A86-48568
- Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769

- Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack p 770 A86-48825
- Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045

- PN/S calculations for a fighter W/F at high-lift yaw conditions — parabolized Navier-Stokes computer code
[AIAA PAPER 86-1829] p 779 A86-49588
- Validation of a full potential method for combined yaw and angle of attack
[AIAA PAPER 86-1834] p 779 A86-49591
- Cancellation zone in supersonic lifting wing theory p 780 A86-49824

- High speed viscous flow calculations about complex configurations
[NASA-TM-88237] p 850 N86-31827

SUPersonic FLUTTER

- Splitter blades as an aeroelastic detuning mechanism for unstalled supersonic flutter of turbomachine rotors
[ASME PAPER 86-GT-99] p 813 A86-48164
- On the optimization of flutter characteristics of laminated anisotropic cylindrical shells p 848 A86-49082
- Oscillating wings and bodies with flexure in supersonic flow Applications of harmonic potential panel method p 776 A86-49108

SUPersonic INLETS

- Wave drag of a supersonic air intake at high subsonic velocities p 770 A86-48834

SUPersonic JET FLOW

- Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804

SUPersonic TRANSPORTS

- The impact of emerging technologies on an advanced supersonic transport p 761 A86-48997

SUPersonic TURBINES

- Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage
[ASME PAPER 86-GT-56] p 765 A86-48134

SURGES

- The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306

SURVEILLANCE RADAR

- Secondary radar leads - Monopulse points the way p 787 A86-48372

SUSPENDING (HANGING)

- Dynamics of a helicopter with a sling load
[AIAA PAPER 86-2288] p 831 A86-47709

SWEEP ANGLE

- Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779

SWEEP EFFECT

- Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB)
[ESA-TT-916-PT-2] p 782 N86-31542

SWEEP FORWARD WINGS

- Divergence of an anisotropic sweptforward wing p 768 A86-48788
- Transonic flow past the root section of a wing with sweepback and sweepforward p 769 A86-48817
- The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056
- A general formulation for the aeroelastic divergence of composite sweptforward wing structures p 802 A86-49095
- Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip
[NASA-TM-87722] p 781 N86-31532

SWEEP WINGS

- Vortex-induced effects on aircraft dynamics
[AIAA PAPER 86-2279] p 830 A86-47697
- Comparisons in three-dimensionality in the unsteady flows elicited by straight and swept wings
[AIAA PAPER 86-2280] p 764 A86-47698
- Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769

- Method for the visualization of subsonic gas flows p 769 A86-48808

- Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027

- Leading edge vortex flow over a 75 degree-swept delta wing Experimental and computational results [ONERA, TP NO. 1986-122] p 773 A86-49042
- Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043
- Method of analysing data on a swept wing aircraft in flight p 775 A86-49103
- Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg [AIAA PAPER 86-1775] p 777 A86-49579
- SWEEPBACK WINGS**
- Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing [AAAF PAPER NT 85-03] p 786 A86-48454
- Transonic flow past the root section of a wing with sweepback and sweepforward p 789 A86-48817
- Aeroelastic tailoring of aft-swept high aspect ratio composite wings p 802 A86-49097
- SWITCHING CIRCUITS**
- Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305
- SYNCHROPHASING**
- Noise control characteristics of synchrophasing. II - Experimental investigation — on aircraft fuselage model p 805 A86-49808
- SYSTEM EFFECTIVENESS**
- An analytical methodology for predicting repair time distributions of advanced technology aircraft [AD-A167149] p 783 N86-31529
- SYSTEM FAILURES**
- Robust fault detection and isolation for a high performance aircraft on STOL approach [AIAA PAPER 86-2031] p 821 A86-47421
- Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507
- SYSTEM IDENTIFICATION**
- An explicit adaptive flight control system based on the modified gain extended Kalman filter [AIAA PAPER 86-2158] p 823 A86-47465
- Identification of pilot dynamics in a system with a choice of feedback structures p 825 A86-47496
- Identification of gust input and gust response characteristics from Do 28 TNT flight test data [ESA-TT-919] p 837 N86-32445
- SYSTEMS ANALYSIS**
- A fundamental approach to equivalent systems analysis — in evaluating aircraft handling qualities [AIAA PAPER 86-2128] p 828 A86-47674
- SYSTEMS ENGINEERING**
- System design and integration of the large-scale advanced prop-fan [NASA-CR-174789] p 781 N86-31536
- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AD-A167717] p 781 N86-31539
- Aeropropulsion opportunities for the 21st century [NASA-TM-88817] p 819 N86-31585
- SYSTEMS INTEGRATION**
- Aircraft/engine integration for an advanced fighter considering mission specifics [ASME PAPER 86-GT-295] p 797 A86-48308
- Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- SYSTEMS SIMULATION**
- Design of a fast risetime lightning generator p 837 A86-47304
- Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305
- Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307
- High voltage laboratory tests and lightning phenomena p 844 A86-47312
- T**
- T-33 AIRCRAFT**
- Turbulence response matching in the NT-33A in-flight simulator [AIAA PAPER 86-2076] p 827 A86-47665
- TACTICS**
- Harrier the viffer — vectoring in forward flight as fighter aircraft combat maneuver p 763 A86-49681
- TAIL ASSEMBLIES**
- A comparison of pod and tail mounted ramjets p 818 A86-49112
- Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load p 849 A86-49128
- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AD-A167717] p 781 N86-31539

TAKEOFF

- Optimization and acceleration guidance of flight trajectories in a windshear p 822 A86-47425
- [AIAA PAPER 86-2038] p 822 A86-47425
- Take-off and landing in a downburst p 786 A86-49069
- Development of a takeoff performance monitoring system [NASA-TM-89001] p 835 N86-31591
- TAKEOFF RUNS**
- Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121
- TAYLOR SERIES**
- Truncated Taylor series solutions to a generalized Burgers' equation p 858 A86-49716
- TECHNOLOGICAL FORECASTING**
- Aeroelasticity today and tomorrow [ONERA, TP NO. 1986-105] p 800 A86-48978
- Future trends in propulsion p 816 A86-48979
- TECHNOLOGIES**
- The theoretical basis of helicopter technology; Proceedings of the Seminar, Nanjing, People's Republic of China, November 6-8, 1985, Parts 1, 2, 3, 4, & 5 p 761 A86-48651
- TECHNOLOGY ASSESSMENT**
- Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 760 A86-47609
- The impact of emerging technologies on an advanced supersonic transport p 761 A86-48997
- A propfan status report p 817 A86-49091
- Propfan and turbofan - Antagonism or synthesis p 817 A86-49092
- Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2 [BMFT-FB-W-85-022] p 808 N86-31577
- An overview of the Small Engine Component Technology (SECT) studies [NASA-TM-88796] p 819 N86-31587
- TECHNOLOGY TRANSFER**
- High-angle-of-attack aerodynamics - Lessons learned [AIAA PAPER 86-1774] p 777 A86-49578
- TECHNOLOGY UTILIZATION**
- Use and maintenance of helicopters on the plateau — areas of China p 785 A86-48669
- TEMPERATURE COMPENSATION**
- Practical applications of Tesla semiconductor pressure sensors p 849 A86-49148
- TEMPERATURE DISTRIBUTION**
- Perspectives on dilution jet mixing — in creating temperature patterns at combustor exits in gas turbine engines [AIAA PAPER 86-1611] p 818 A86-49614
- TEMPERATURE PROBES**
- Multiple thermocouple testing device [AD-D012276] p 850 N86-31860
- TEMPERATURE PROFILES**
- Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust [AIAA PAPER 86-1809] p 778 A86-49585
- TENSOMETERS**
- Strain-gauge autopilot altitude corrector p 811 A86-49142
- Application of strain gauge amplifiers and computer technology to the strength testing of aircraft p 849 A86-49144
- TERMINAL GUIDANCE**
- Terminal control factors for the carrier landing task [AIAA PAPER 86-2251] p 825 A86-47497
- Pilot evaluation of experimental flight trajectories in the near-terminal area [AIAA PAPER 86-2074] p 838 A86-47664
- TERRAIN**
- Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations [NASA-TM-86779] p 789 N86-31551
- TERRAIN FOLLOWING AIRCRAFT**
- Rotary-wing aircraft terrain-following/terrain-avoidance system development [AIAA PAPER 86-2147] p 823 A86-47456
- Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783
- TEST FACILITIES**
- Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307
- Society of Flight Test Engineers, Annual Symposium, 16th, Seattle, WA, July 29-August 2, 1985, Proceedings p 794 A86-47776
- The F2 wind tunnel of the Fauga-Mauzac Test Center [ONERA, TP NO. 1986-104] p 839 A86-49075
- TEST STANDS**
- Design of a vertical thrust stand for a remotely piloted model helicopter [AD-A167811] p 840 N86-31598

TF-34 ENGINE

- Durability and damage tolerance assessment of the TF34-100 engine [ASME PAPER 86-GT-38] p 812 A86-48125
- THERMAL DECOMPOSITION**
- Thermal decomposition of aircraft fuel [ASME PAPER 86-GT-36] p 842 A86-48123
- THERMAL ENVIRONMENTS**
- Heat management in advanced aircraft gas turbine engines [ASME PAPER 86-GT-76] p 813 A86-48144
- THERMAL MAPPING**
- Applications of thermal imager devices incl. modelling aspects [MBB-UD-462-85-OE] p 850 A86-50254
- THERMAL RESISTANCE**
- Elevated-temperature-resistant adhesives p 842 A86-47717
- THERMAL STABILITY**
- Thermal stability concerns of Navy aviation fuel [ASME PAPER 86-GT-94] p 842 A86-48159
- Advanced polymer composites for high temperature applications p 843 A86-49021
- THERMAL STRESSES**
- Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads [ASME PAPER 86-GT-172] p 815 A86-48224
- Optimum design technique for rotating wheels [ASME PAPER 86-GT-255] p 846 A86-48281
- THERMOCOUPLES**
- Multiple thermocouple testing device [AD-D012276] p 850 N86-31860
- THERMOPLASTIC RESINS**
- Materials in aerospace - Can the emerging thermoplastics meet the challenge? p 843 A86-49020
- THIN AIRFOILS**
- Determination of off-design flowrates according to the position of branching points on an under-the-wing (over-the-wing) air intake p 769 A86-48812
- Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model p 776 A86-49245
- System design and integration of the large-scale advanced prop-fan [NASA-CR-174789] p 781 N86-31536
- THIN WALLS**
- Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776
- THIN WINGS**
- Cancellation zone in supersonic lifting wing theory p 780 A86-49824
- THREAT EVALUATION**
- Airborne intruder detection considerations [DE86-006462] p 808 N86-31576
- THREE DIMENSIONAL BOUNDARY LAYER**
- Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing [AAAF PAPER NT 85-03] p 786 A86-48454
- Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
- THREE DIMENSIONAL FLOW**
- Comparisons in three-dimensionality in the unsteady flows elicited by straight and swept wings [AIAA PAPER 86-2280] p 764 A86-47698
- A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method [ASME PAPER 86-GT-111] p 785 A86-48173
- Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809
- The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833
- Efficient solution of three-dimensional Euler equations using embedded grids p 771 A86-49007
- Wake/boundary-layer interactions in two and three dimensions p 773 A86-49032
- Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043
- Three-dimensional transonic flow computations on simple skewed grids [AIAA PAPER 86-1794] p 778 A86-49581
- Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- THREE DIMENSIONAL MOTION**
- Spherical mapping and analysis of aircraft angles for maneuvering flight [AIAA PAPER 86-2283] p 830 A86-47701
- Near-optimal feedback control for three-dimensional interceptions p 854 A86-48992

THROTTLING

The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation
p 816 A86-48757

THRUST

The application of energy techniques to propeller-driven airplanes
[AD-A167113] p 807 N86-31569
Design of a vertical thrust stand for a remotely piloted model helicopter
[AD-A167811] p 840 N86-31598

THRUST CONTROL

Case studies of the effects on non-linearities on the accuracy of gas turbine control
p 817 A86-49090

THUNDERSTORMS

The energy requirements of an aircraft triggered discharge
p 844 A86-47315
Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane
p 791 A86-47318
Aircraft protection against lightning strikes
p 806 A86-50347

TILT ROTOR AIRCRAFT

A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575

TIME LAG

Effect of time delay on flying qualities - An update
[AIAA PAPER 86-2202] p 823 A86-47482
Effects of time delay and pitch control sensitivity in the flared landing
[AIAA PAPER 86-2075] p 831 A86-47706
On control concept for in-flight simulation including actuator nonlinearities and time delays
[ESA-TT-948] p 836 N86-31593

TIME OPTIMAL CONTROL

Time scale analysis of a closed-loop discrete optimal control system
[AIAA PAPER 86-1995] p 852 A86-47417
Aerodynamic delay following control actuation in a glider
[AIAA PAPER 86-2226] p 829 A86-47689

TIME RESPONSE

Design factors and considerations for a time-based flight management system
[AIAA PAPER 86-2144] p 822 A86-47455

TITANIUM

Low mass diffusion bonding tools
[AD-D012295] p 851 N86-32746

TITANIUM ALLOYS

Aeroelastic behavior of low aspect ratio metal and composite blades
[ASME PAPER 86-GT-243] p 846 A86-48271

TOLERANCES (MECHANICS)

Evaluation of damage tolerance requirements using a probabilistic-based life approach
[ASME PAPER 86-GT-266] p 847 A86-48288
Cost reductions from introduction of new life philosophies for aircraft engine discs
[NLR-MP-85076-U] p 820 N86-32438

TOOLS

Low mass diffusion bonding tools
[AD-D012295] p 851 N86-32746

TORQUE

Manufacturing technology of composite torque box of vertical fin
p 848 A86-49068

TORQUEMETERS

Contactless measurement of the torque of an aircraft engine
p 849 A86-49145

TORSION

Rotor aeroelastic stability
p 798 A86-48664

TORSO

Evaluation of a pre-ejection upper torso retraction device
p 793 A86-47728

TRACKING PROBLEM

A controller for robust asymptotic tracking in systems with time-varying uncertainties
[AIAA PAPER 86-2199] p 853 A86-47479

TRADEOFFS

A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575

TRAILING EDGES

A new, improved method for separating turbulent boundary layer for aerodynamic performance prediction of trailing edge stall airfoils
[AIAA PAPER 86-1832] p 779 A86-49590
Airfoil trailing-edge flow measurements
p 780 A86-49803
Computation of the potential flow over airfoils with cusped or thin trailing edges
p 780 A86-49823

TRAINING AIRCRAFT

T-46A - The USAF next generation trainer
p 796 A86-47796

TRAJECTORY OPTIMIZATION

Optimization and acceleration guidance of flight trajectories in a windshear
[AIAA PAPER 86-2036] p 822 A86-47425
A study of aircraft cruise
[AIAA PAPER 86-2286] p 792 A86-47704
Direct trajectory optimization using nonlinear programming and collocation
[AIAA PAPER 86-2000] p 841 A86-47902
Optimization and gamma/theta guidance of flight trajectories in a windshear
p 834 A86-49071

TRANSDUCERS

Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller
[AIAA PAPER 86-1893] p 780 A86-49625

TRANSFER FUNCTIONS

Pitch rate sensitivity criterion for category C flight phases - Class IV aircraft
[AIAA PAPER 86-2201] p 823 A86-47481
Precise solution for rational transfer parameters of flight vehicles
p 801 A86-49022

TRANSIENT RESPONSE

A general computational method for simulation and prediction of transient behavior of gas turbines
[ASME PAPER 86-GT-180] p 815 A86-48230
Nonlinear dynamics or rotor/blade/casing rub interactions
[ASME PAPER 86-DE-6] p 818 A86-49620

TRANSITION LAYERS

Interior transition layers in flight path optimization
[AIAA PAPER 86-2037] p 797 A86-48576

TRANSMISSION LOSS

The effect on the transmission loss of a double wall panel of using helium gas in the gap
p 855 A86-48590

TRANSMISSIONS (MACHINE ELEMENTS)

Transmission design using finite element method analysis techniques
p 847 A86-48658

TRANSONIC FLIGHT

The effect of the aspect ratio of the cylindrical section on the fuselage drag at transonic flight velocities
p 768 A86-48801

TRANSONIC FLOW

The effect of a downstream rotor on the measured performance of a transonic turbine nozzle
[ASME PAPER 86-GT-103] p 814 A86-48166
Development of an experimental correlation for transonic turbine flow
[ASME PAPER 86-GT-108] p 765 A86-48170
Numerical solution of transonic stream function equation on S1 stream surface in cascade
[ASME PAPER 86-GT-110] p 765 A86-48172
A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method
[ASME PAPER 86-GT-111] p 765 A86-48173
A method for transonic inverse cascade design with a stream function equation
[ASME PAPER 86-GT-189] p 766 A86-48239
Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results - German thesis
p 767 A86-48568
Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream
p 769 A86-48809
Transonic flow past the root section of a wing with sweepback and sweepforward
p 769 A86-48817
Wave drag of a supersonic air intake at high subsonic velocities
p 770 A86-48834
Transonic computations about complex configurations using coupled inner and outer flow equations
p 771 A86-49008
Application of the TranAir full-potential code to complete configurations
p 772 A86-49009
Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows
p 774 A86-49045
Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model
p 776 A86-49245
Prediction of gust loadings and alleviation at transonic speeds
[AIAA PAPER 86-0997] p 777 A86-49573
Three-dimensional transonic flow computations on simple skewed grids
[AIAA PAPER 86-1794] p 778 A86-49581
Transonic wave drag estimation and optimization using the nonlinear area rule
[AIAA PAPER 86-1798] p 778 A86-49582
Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches
[AIAA PAPER 86-1821] p 778 A86-49586
Navier-Stokes simulation of transonic flow over wing-fuselage combinations
[AIAA PAPER 86-1831] p 779 A86-49589

Transonic airfoil calculations including wind tunnel wall-interference effects
p 780 A86-49825
ATRAN3S: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535
Computations of separated subsonic and transonic flow about airfoils in unsteady motion
[NLR-MP-84094-U] p 782 N86-31541
Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation
[NASA-TM-88248-PT-2] p 782 N86-32392
Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA
[ONERA-RT-19/3463-AYP] p 841 N86-32451

TRANSONIC FLUTTER

Subsonic/transonic stall flutter investigation of an advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
Applications of potential theory computations to transonic aeroelasticity
p 775 A86-49105
Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 N86-31568

TRANSONIC WIND TUNNELS

Advances at AEDC in treating transonic wind tunnel wall interference
p 839 A86-49058
Numerical design parameter study for slotted walls in transonic wind tunnels
p 839 A86-49059
Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB)
[ESA-TT-916-PT-2] p 782 N86-31542

TRANSPORT AIRCRAFT

Lightning-induced transient test on a transport aircraft
p 791 A86-47327
Thirty years with the jets: Commercial transport flight management systems - Past, present, and future
[AIAA PAPER 86-2289] p 821 A86-47402
Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance
p 780 A86-47609
Use of flight simulation to develop terminal instrument procedures for transport category aircraft
[AIAA PAPER 86-2072] p 837 A86-47662
A study of aircraft cruise
[AIAA PAPER 86-2286] p 792 A86-47704
A new look at inflight loads on existing transport aircraft
p 796 A86-47794
The GTPC36-300 - A gas turbine auxiliary power unit for advanced technology transport aircraft
[ASME PAPER 86-GT-285] p 816 A86-48302
Thick supercritical airfoils with low drag and NLF capability
p 771 A86-48981
Investigations on high Reynolds number laminar flow airfoils
p 771 A86-48983
Influence of EFCS-control laws on structural design of modern transport aircraft
p 800 A86-48984
Avionics fault data acquisition - A concept for civil transport aircraft
p 810 A86-49051
Structural dynamics research in a full-scale transport aircraft crash test
p 785 A86-49053
A study of the structural integrity of the Canadair Challenger at ditching
p 785 A86-49054
Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method
p 839 A86-49060
Application of strain gauge methods to determination of in-flight loads of structure groups of small transport aircraft
p 811 A86-49149
Navier-Stokes simulation of transonic flow over wing-fuselage combinations
[AIAA PAPER 86-1831] p 779 A86-49589
Laminar flow research applicable to subsonic aircraft
p 781 A86-50269
International Aviation (selected articles)
[AD-A166298] p 763 N86-31528
Aerodynamic design methods for modern transport aircraft
[ESA-TT-923] p 782 N86-31543

TRAPPED VORTEXES

Trapping of a free vortex by airfoils with surface suction
p 780 A86-49801

TUNERS

Splitter blades as an aeroelastic detuning mechanism for uninstalled supersonic flutter of turbomachine rotors
[ASME PAPER 86-GT-99] p 813 A86-48164

TURBINE BLADES

Development of an experimental correlation for transonic turbine flow
[ASME PAPER 86-GT-108] p 765 A86-48170
Aeroelastic behavior of low aspect ratio metal and composite blades
[ASME PAPER 86-GT-243] p 846 A86-48271
Single crystal superalloys for turbine blades in advanced aircraft engines
[ONERA, TP NO. 1986-102] p 843 A86-49077

U

System design and integration of the large-scale advanced prop-fan
[NASA-CR-174789] p 781 N86-31536

TURBINE ENGINES
Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads
[ASME PAPER 86-GT-172] p 815 A86-48224

TURBINE EXHAUST NOZZLES
Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust
[AIAA PAPER 86-1809] p 778 A86-49585

TURBINE WHEELS
Comparison of methods for lifetime calculations of highly loaded aero-engine discs
[ASME PAPER 86-GT-102] p 814 A86-48165
A contribution to airworthiness certification of gas turbine disks
p 849 A86-49136

TURBINES
The effect of a downstream rotor on the measured performance of a transonic turbine nozzle
[ASME PAPER 86-GT-103] p 814 A86-48166
Advances in turbine technology p 817 A86-49079

TURBOCOMPRESSORS
The use of surface static pressure data as a diagnostic tool in multistage compressor development
[ASME PAPER 86-GT-3] p 812 A86-48103
Evaluation of the blade-to-blade flow from a high speed compressor rotor
[ASME PAPER 86-GT-117] p 765 A86-48176
Optimum design technique for rotating wheels
[ASME PAPER 86-GT-255] p 846 A86-48281
Quality assurance in the reconditioning of gas turbine and compressor blading components
[ASME PAPER 86-GT-299] p 847 A86-48311
The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation
p 816 A86-48757
Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064

TURBOFAN ENGINES
Flight testing of general electric high bypass engines evolution and revolution p 812 A86-47786
Re-engine KC-135R/CFM56 flight test program - An overview p 795 A86-47793
T-46A - The USAF next generation trainer
p 796 A86-47796
An artificial intelligence approach to onboard fault monitoring and diagnosis for aircraft applications
[AIAA PAPER 86-2093] p 853 A86-48577
Modelling of acoustic radiation problems associated with turbomachinery and rotating blades p 855 A86-48597
The M53 turbofan control system - A strong basis for the development of the future digital control systems
p 817 A86-49088
Propfan and turbofan - Antagonism or synthesis
p 817 A86-49092
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight
p 856 A86-49806
An overview of the Small Engine Component Technology (SECT) studies
[NASA-TM-88796] p 819 N86-31587
Multiple thermocouple testing device
[AD-D012276] p 850 N86-31860

TURBOFANS
Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan
[ASME PAPER 86-GT-98] p 813 A86-48163

TURBOJET ENGINE CONTROL
The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation
p 816 A86-48757

TURBOJET ENGINES
A jet fuel starter and expendable turbojet
[ASME PAPER 86-GT-1] p 812 A86-48101

TURBOMACHINE BLADES
A method for transonic inverse cascade design with a stream function equation
[ASME PAPER 86-GT-189] p 766 A86-48239

TURBOMACHINERY
Numerical solution of transonic stream function equation on S1 stream surface in cascade
[ASME PAPER 86-GT-110] p 765 A86-48172
A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method
[ASME PAPER 86-GT-111] p 765 A86-48173
Modelling of acoustic radiation problems associated with turbomachinery and rotating blades p 855 A86-48597
The role of flow field computation in improving turbomachinery p 775 A86-49080

TURBOPROP AIRCRAFT

Control of interior noise in advanced turbopropeller aircraft p 802 A86-49100
Noise control characteristics of synchrophasing. II - Experimental investigation --- on aircraft fuselage model
p 805 A86-49808

TURBOPROP ENGINES

Quantifying a propeller/engine power response rate mismatch p 796 A86-47801
Operation of the CT7 turboprop engine as an auxiliary power unit (APU)
[ASME PAPER 86-GT-28] p 812 A86-48119
Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
System design and integration of the large-scale advanced prop-fan
[NASA-CR-174789] p 781 N86-31536
An overview of the Small Engine Component Technology (SECT) studies
[NASA-TM-88796] p 819 N86-31587

TURBORAMJET ENGINES

A parametric study of a gas-generator air turbo ramjet (ATR)
[NASA-TM-88808] p 819 N86-31586

TURBOSHAFTS

Power level influence on architecture of small helicopter turboshaft engines
[ASME PAPER 86-GT-191] p 815 A86-48241

TURBULENCE

Six degree of freedom simulation software
[NAL-PD-SE-8614] p 854 N86-33042

TURBULENCE EFFECTS

Limitations of statically unstable aircraft due to the effects of sensor noise, turbulence, and structural dynamics
[AIAA PAPER 86-2203] p 824 A86-47483
Turbulence response matching in the NT-33A in-flight simulator
[AIAA PAPER 86-2076] p 827 A86-47665
Calculation of the loading of the airframe in flight due to multidimensional turbulence p 799 A86-48759

TURBULENT BOUNDARY LAYER

Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing
[AAAF PAPER NT 85-03] p 766 A86-48454
Reduction of turbulent drag - Turbulence manipulators
[AAAF PAPER NT 85-04] p 766 A86-48455
Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031
A new, improved method for separating turbulent boundary layer for aerodynamic performance prediction of trailing edge stall airfoils
[AIAA PAPER 86-1832] p 779 A86-49590

TURBULENT FLOW

Reduction of turbulent drag - Turbulence manipulators
[AAAF PAPER NT 85-04] p 766 A86-48455
An experimental study of turbulent wake/boundary layer mixing flows p 772 A86-49014
Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence
p 772 A86-49027
Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model p 776 A86-49245
Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels
[NASA-TM-87316] p 820 N86-31588
High speed viscous flow calculations about complex configurations
[NASA-TM-88237] p 850 N86-31827

TURBULENT WAKES

An experimental study of turbulent wake/boundary layer mixing flows p 772 A86-49014

TURNING FLIGHT

Optimal descending, hypersonic turn to heading
[AIAA PAPER 86-2134] p 841 A86-47679

TWO DIMENSIONAL FLOW

Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809
Wake/boundary-layer interactions in two and three dimensions p 773 A86-49032
Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows
[ONERA, TP NO. 1986-101] p 776 A86-49106
Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches
[AIAA PAPER 86-1821] p 778 A86-49586

TWO PHASE FLOW

Particulate flow solutions through centrifugal impeller with two splitters
[ASME PAPER 86-GT-130] p 785 A86-48188

ULLAGE

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573

ULTRALIGHT AIRCRAFT

Long endurance aircraft performance p 805 A86-49478

ULTRASONIC TESTS

The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102

UNIQUENESS THEOREM

Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme p 769 A86-48822

UNSTEADY FLOW

Unsteady low-speed aerodynamic model for complete aircraft configurations
[AIAA PAPER 86-2180] p 829 A86-47683
Comparisons in three-dimensionality in the unsteady flows elicited by straight and swept wings
[AIAA PAPER 86-2280] p 764 A86-47698
Visualization of dynamic stall controlled by large amplitude interrupted pitching motions
[AIAA PAPER 86-2281] p 764 A86-47699
Unsteady aerodynamics - Fundamental aspects and applications to aircraft dynamics
[AAAF PAPER NT 85-16] p 767 A86-48465
A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers
p 847 A86-48647
The aerodynamic potential of anti-sound
p 855 A86-48977
Prediction of the aerodynamic characteristics of flight vehicles in large unsteady maneuvers
p 834 A86-49048

Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows
[ONERA, TP NO. 1986-101] p 776 A86-49106
An entropy correction method for unsteady full potential flows with strong shocks
[AIAA PAPER 86-1768] p 777 A86-49576
Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller
[AIAA PAPER 86-1893] p 780 A86-49625
ATRAN3S: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535

USER MANUALS (COMPUTER PROGRAMS)

ATRAN3S: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535

USER REQUIREMENTS

The MIL-prime standard for aircraft flying qualities
[AIAA PAPER 86-2131] p 828 A86-47677
Adhesive selection from the user's viewpoint p 841 A86-47715

V

VARIABLE SWEEP WINGS

The dynamic response of a variable sweep aircraft in the course of changing geometry
[AIAA PAPER 86-2234] p 829 A86-47694

VERTICAL MOTION

Frequency and time domain designs of a strapdown vertical determination system
[AIAA PAPER 86-2148] p 810 A86-47457

VERTICAL TAKEOFF AIRCRAFT

Modern developments in rotorcraft technology
[MBB-UD-458-85-OE] p 805 A86-49509
A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP
[AD-A167719] p 808 N86-31575
Design of a vertical thrust stand for a remotely piloted model helicopter
[AD-A167811] p 840 N86-31598

VIBRATION DAMPING

Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft
[AIAA PAPER 86-2243] p 824 A86-47491
Coupled aeroelastic hub loads reduction
p 799 A86-48665
Research on active suppression technology for wing/aileron flutter p 835 A86-49096
Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 N86-31568
Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter
[SNIAS-861-210-108] p 836 N86-32444

VIBRATION ISOLATORS

- Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter
[SNIAS-861-210-108] p 836 N86-32444

VIBRATION MEASUREMENT

- New methods for in-flight vibration testing p 820 A86-47369

VIBRATION MODE

- Real-time flutter identification with close mode resolution
[AIAA PAPER 86-2019] p 827 A86-47654

VIBRATION TESTS

- New methods for in-flight vibration testing p 820 A86-47369
- Identification of unsteady response in rudders at low velocities
[AAAF PAPER NT 85-19] p 797 A86-48468
- Developments in helicopter ground vibration testing p 805 A86-49638
- Dynamic analysis: Correlation of theory with experiment -- MSC/NASTRAN analysis of Westland 30 G-BGHF [RP661] p 851 N86-31917
- Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter
[SNIAS-861-210-108] p 836 N86-32444

VISCOSITY

- Analytical applications in the Army oil analysis program p 845 A86-47595

VISCIOUS FLOW

- High speed viscous flow calculations about complex configurations
[NASA-TM-88237] p 850 N86-31827

VISUAL FLIGHT RULES

- Civil helicopter handling qualities requirements for visual and instrument flight p 832 A86-48674

VOLTAGE GENERATORS

- Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305

VORTEX BREAKDOWN

- Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046

VORTEX FILAMENTS

- A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack p 767 A86-48762

VORTEX GENERATORS

- Low-speed aerodynamics of apex fences on a tailless delta configuration
[AIAA PAPER 86-1838] p 779 A86-49593

VORTEX SHEDDING

- Control of wake structure behind an oscillating airfoil
[AIAA PAPER 86-2282] p 764 A86-47700
- Leading edge vortex flow over a 75 degree-swept delta wing. Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
- Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043
- Forebody vortex management for yaw control at high angles of attack p 833 A86-49047

VORTEX SHEETS

- The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833

- Flow of an ideal fluid in the core of a vortex sheet p 770 A86-48839

- Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049

VORTICES

- Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack
[AIAA PAPER 86-2277] p 830 A86-47695

- Vortex-induced effects on aircraft dynamics
[AIAA PAPER 86-2279] p 830 A86-47697

- The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671

- A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842

- Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027

- Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045

- Analysis of the vortical flow around a 60 degree delta wing with vortex flap p 774 A86-49050

- The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102

- Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592

- Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258

VULNERABILITY

- Survivability considerations during aircraft conceptual design
[AD-A168555] p 809 N86-32428

W

WAKES

- A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842
- The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102

WALLS

- The effect on the transmission loss of a double wall panel of using helium gas in the gap p 855 A86-48590

WARNING SYSTEMS

- Ranging and azimuthal problems of an airborne crossed loop used as a single-station lightning locator p 809 A86-47325

- F-5E departure warning system algorithm development and validation
[AIAA PAPER 86-2284] p 830 A86-47702

- Obstacle warning radar for helicopters - An anthropotechnical problem p 787 A86-47769

WATER LANDING

- Emergency underwater escape from helicopters p 784 A86-47745

WATER PRESSURE

- Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels
[ASME PAPER 86-GT-163] p 843 A86-48216

WATER TAKEOFF AND LANDING AIRCRAFT

- Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577

WATER TUNNEL TESTS

- Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack
[AIAA PAPER 86-2277] p 830 A86-47695

WAVE DRAG

- Wave drag of a supersonic air intake at high subsonic velocities p 770 A86-48834

WAVE FRONT RECONSTRUCTION

- Aerodynamic design methods for modern transport aircraft
[ESA-TT-923] p 782 N86-31543

WAVEFORMS

- Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems
[AD-A167400] p 856 N86-32249

WEAPON SYSTEMS

- Life cycle cost methodology for preliminary design evaluation
[ASME PAPER 86-GT-37] p 812 A86-48124

- Durability and damage tolerance assessment of the TF34-100 engine
[ASME PAPER 86-GT-38] p 812 A86-48125

- An analytical methodology for predicting repair time distributions of advanced technology aircraft
[AD-A167149] p 763 N86-31529

WEAR INHIBITORS

- The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963

WEIGHT ANALYSIS

- Weight estimation techniques for composite airplanes in general aviation industry
[NASA-CR-178163] p 781 N86-31531

WEIGHT MEASUREMENT

- Studies for the application of a flexible weight and balance (W/B) measuring facility for commercial aircraft
[BMFT-FB-W-85-029] p 840 N86-31604

WEIGHT REDUCTION

- Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830

- Automated structural optimisation at Warton -- for aircraft p 854 A86-48987

WEIGHTING FUNCTIONS

- Automated pole placement algorithm for multivariable optimal control synthesis
[AIAA PAPER 86-2196] p 852 A86-47476

WIDE ANGLE LENSES

- An improved optical viewing system for a flight simulator
[MS-8025] p 840 N86-32448

WIND EFFECTS

- The analysis of airline flight records for winds and performance with application to the Delta 191 accident
[AIAA PAPER 86-2227] p 829 A86-47690

- Flow stagnation as an advanced windblast protection technique -- for ejection seat safety p 793 A86-47727

- Wind influence on the range of jet or propeller aircraft p 801 A86-48990

WIND SHEAR

- Evaluation of total energy-rate feedback for glidescope tracking in wind shear
[AIAA PAPER 86-2035] p 822 A86-47424

- Optimization and acceleration guidance of flight trajectories in a windshear
[AIAA PAPER 86-2036] p 822 A86-47425

- Take-off and landing in a downburst p 786 A86-49069

- Optimization and gamma/theta guidance of flight trajectories in a windshear p 834 A86-49071

WIND TUNNEL MODELS

- The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056

- Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip
[NASA-TM-87722] p 781 N86-31532

- A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure
[NAL-TRM-SE-8603] p 782 N86-32393

WIND TUNNEL STABILITY TESTS

- Identification of unsteady response in rudders at low velocities
[AAAF PAPER NT 85-19] p 797 A86-48468

WIND TUNNEL TESTS

- Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model
[AIAA PAPER 86-2242] p 824 A86-47490

- Advanced icing wind tunnel for flight test development of icing rate systems p 838 A86-47792

- Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457

- Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results -- German thesis p 767 A86-48568

- Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767

- Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824

- Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981

- Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control p 833 A86-49039

- Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044

- Analysis of the vortical flow around a 60 degree delta wing with vortex flap p 774 A86-49050

- Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057

- Advances at AEDC in treating transonic wind tunnel wall interference p 839 A86-49058

- Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method p 839 A86-49060

- Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061

- The F2 wind tunnel of the Fauga-Mauzac Test Center
[ONERA, TP NO. 1986-104] p 839 A86-49075

- The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102

- Airfoil trailing-edge flow measurements p 780 A86-49803

- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations
[AD-A167717] p 781 N86-31539

- Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB)
[ESA-TT-916-PT-2] p 782 N86-31542

- The A-320 aerodynamics. The turbofan air inlet
[NOTE-427.021/86] p 806 N86-31567

- Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels
[NASA-TM-87316] p 820 N86-31588

- A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure
[NAL-TRM-SE-8603] p 782 N86-32393

- Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA
[ONERA-RT-19/3463-AYP] p 841 N86-32451

WIND TUNNEL WALLS

- Advances at AEDC in treating transonic wind tunnel wall interference p 839 A86-49058
- Numerical design parameter study for slotted walls in transonic wind tunnels p 839 A86-49059
- Transonic airfoil calculations including wind tunnel wall-interference effects p 780 A86-49825

WIND TUNNELS

- Aeracoustics at the German-Dutch wind tunnel p 839 A86-49061
- Wind tunnels battle the number-crunchers p 840 A86-49683

WINDS ALOFT

- The INS wind calibration in climb algorithm p 796 A86-47799

WINDSHIELDS

- Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055

WING FLAPS

- Flight control system development and flight test experience with the F-111 mission adaptive wing aircraft [AIAA PAPER 86-2237] p 824 A86-47489
- Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782

WING FLOW METHOD TESTS

- Comparisons in three-dimensionality in the unsteady flows elicited by straight and swept wings [AIAA PAPER 86-2280] p 764 A86-47698
- Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results -- German thesis p 767 A86-48568
- Leading edge vortex flow over a 75 degree-swept delta wing Experimental and computational results [ONERA, TP NO. 1986-122] p 773 A86-49042
- The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174
- Airfoil trailing-edge flow measurements p 780 A86-49803

WING LOADING

- Determination of the required number of channels for controlling aircraft wing loading for several cases of calculation p 768 A86-48787
- Residual strength prediction for planked wing tension surfaces [AIAA PAPER 86-0941] p 849 A86-49572

WING NACELLE CONFIGURATIONS

- Determination of off-design flowrates according to the position of branching points on an under-the-wing (over-the-wing) air intake p 769 A86-48812
- On the computation of wing lift interference caused by high bypass engines p 776 A86-49109
- Wing laminar boundary layer in the presence of a propeller slipstream p 776 A86-49122

WING OSCILLATIONS

- Control of wake structure behind an oscillating airfoil [AIAA PAPER 86-2282] p 764 A86-47700
- Oscillation equations for a helicopter rotor blade p 800 A86-48805
- Research on active suppression technology for wing/aileron flutter p 835 A86-49096
- Applications of potential theory computations to transonic aeroelasticity p 775 A86-49105
- Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows [ONERA, TP NO. 1986-101] p 776 A86-49106
- Oscillating wings and bodies with flexure in supersonic flow Applications of harmonic potential panel method p 776 A86-49108
- Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches [AIAA PAPER 86-1821] p 778 A86-49586

WING PANELS

- The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001
- Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003

WING PROFILES

- Evaluation and reduction of drag [AAAF PAPER NT 85-01] p 766 A86-48452
- Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions [AAAF PAPER NT 85-06] p 838 A86-48457
- An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen p 770 A86-48841
- Calculation of flow over multielement airfoils at high lift p 772 A86-49011

WING ROOTS

- Transonic flow past the root section of a wing with sweepback and sweepforward p 769 A86-48817

WING SPAN

- Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769

WING TIP VORTICES

- Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580

WINGLETS

- International Aviation (selected articles) [AD-A166298] p 763 N86-31528

WINGS

- Acoustic effect on stall hysteresis for low Reynolds number laminar flow p 855 A86-47971
 - Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779
 - Method for calculating pressure distribution on the surfaces of wings with slit mechanization p 768 A86-48806
 - Flow of an ideal fluid in the core of a vortex sheet p 770 A86-48839
 - Modeling the elasticity of a wing structure p 800 A86-48850
 - Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031
 - The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102
 - ATRAM3S: An unsteady transonic code for clean wings [NASA-TM-86783] p 781 N86-31535
 - In-flight photogrammetric measurement of wing ice accretions [NASA-TM-87191] p 806 N86-31562
 - Aspect ratio effects on wings at low Reynolds numbers p 782 N86-32390
 - Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392
- WIRING**
- The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306

X**X-29 AIRCRAFT**

- Sensitivity analysis of high-order digital flight control systems using singular-value concepts [AIAA PAPER 86-2084] p 822 A86-47437
- Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control [AIAA PAPER 86-2017] p 826 A86-47652
- Application of parameter estimation to highly unstable aircraft [AIAA PAPER 86-2020] p 827 A86-47655
- X-29 Technology Demonstrator program status review p 796 A86-47795
- Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip [NASA-TM-87722] p 781 N86-31532

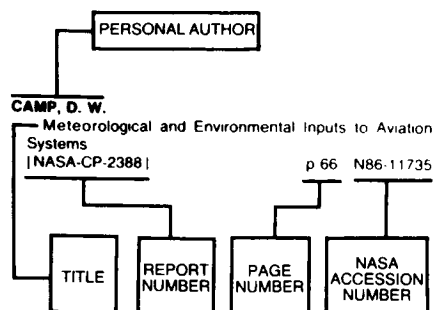
Y**YAG LASERS**

- Interferometric holographic cinematography [ISL-CO-219/85] p 851 N86-31872

YAW

- Forebody vortex management for yaw control at high angles of attack p 833 A86-49047
- PN/S calculations for a fighter W/F at high-lift yaw conditions -- parabolized Navier-Stokes computer code [AIAA PAPER 86-1829] p 779 A86-49588
- Validation of a full potential method for combined yaw and angle of attack [AIAA PAPER 86-1834] p 779 A86-49591

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

- ABBOTT, K. H.**
An artificial intelligence approach to onboard fault monitoring and diagnosis for aircraft applications
[AIAA PAPER 86-2093] p 853 A86-48577
- ABELKIS, P. R.**
Supplemental inspections of aging aircraft
p 845 A86-47525
- ABTAHI, A. A.**
Aspect ratio effects on wings at low Reynolds numbers
p 782 N86-32390
- ACHACHE, M.**
Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter
[SNIAS-861-210-108] p 836 N86-32444
- ACOSTA, W. A.**
Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation
[AIAA PAPER 86-1452] p 818 A86-49611
Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation
[NASA-TM-87304] p 819 N86-31582
- ADAMS, M. B.**
A methodology for evaluating the operational performance of an aircraft in a tactical environment
[AIAA PAPER 86-2095] p 759 A86-47444
- ADAMSE, P. H. C.**
Engine condition monitoring at KLM Royal Dutch Airlines
[ASME PAPER 86-GT-300] p 816 A86-48312
- AGORPOULOS, D.**
Wake/boundary-layer interactions in two and three dimensions
p 773 A86-49032
- AGRELL, N.**
Numerical design parameter study for slotted walls in transonic wind tunnels
p 839 A86-49059
- AIHARA, Y.**
Configuration and trajectory of hypersonic transport with aerothermodynamic control
p 804 A86-49124
- AKED, A.**
Aspects of lightning protection schemes for radomes
p 792 A86-47338

- ALAG, G. S.**
Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft
[AIAA PAPER 86-2243] p 824 A86-47491
Model-following control for an oblique-wing aircraft
[AIAA PAPER 86-2244] p 824 A86-47492
- ALBRECHT, C.**
Transmission design using finite element method analysis techniques
p 847 A86-48658
- ALEKSANDROVICH, E. V.**
Wave drag of a supersonic air intake at high subsonic velocities
p 770 A86-48834
- ALI, A. F.**
Conical grid plate flame stabilizers - Stability and emissions for liquid fuels
[ASME PAPER 86-GT-156] p 842 A86-48210
- AN, J.**
The dynamic response of a variable sweep aircraft in the course of changing geometry
[AIAA PAPER 86-2234] p 829 A86-47694
- ANDERS, W.**
Aircraft/engine integration for an advanced fighter considering mission specifics
[ASME PAPER 86-GT-295] p 797 A86-48308
- ANDERSH, D. J.**
Comparison of published HEMP and natural lightning on the surface of an aircraft
p 783 A86-47293
- ANDERSON, C. L.**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573
- ANDERSON, F. J.**
Optical detection methods for testing of fuel tank lightning ignition hazards
p 791 A86-47309
- ANDREWS, G. E.**
Conical grid plate flame stabilizers - Stability and emissions for liquid fuels
[ASME PAPER 86-GT-156] p 842 A86-48210
- ANNIS, C. G., JR.**
Evaluation of damage tolerance requirements using a probabilistic-based life approach
[ASME PAPER 86-GT-266] p 847 A86-48288
- ANTONA, E.**
Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure
p 848 A86-49003
- ANTONOVA, A. M.**
The problem of flow past a plane delta wing with power-law injection at its surface
p 776 A86-49174
- ARDEMA, M. D.**
Interior transition layers in flight path optimization
[AIAA PAPER 86-2037] p 797 A86-48576
- ARDONCEAU, P. L.**
Computation of the potential flow over airfoils with cusped or thin trailing edges
p 780 A86-49823
- AREND, H.**
Analysis of the costs and weight effects of CFK on air transport structure
p 842 A86-48097
- ARENS, D. R. M.**
A comparison of pod and tail mounted ramjets
p 818 A86-49112
- ARNAL, D.**
Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing
[AAAF PAPER NT 85-03] p 766 A86-48454
- ARNAUTOV, E. V.**
Details of analysis of airplane structure acoustic loading in flight testing
p 804 A86-49129
- ARNEY, A. M.**
A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics
[ARL-AERO-TM-379] p 808 N86-32425
- ASHWORTH, J.**
Comparisons in three-dimensionality in the unsteady flows elicited by straight and swept wings
[AIAA PAPER 86-2280] p 764 A86-47698
- ATIAS, M.**
On the motion of spray drops in the wake of an agricultural aircraft
p 777 A86-49441

- ATWAL, M. S.**
The effect on the transmission loss of a double wall panel of using helium gas in the gap
p 855 A86-48590
Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions
p 799 A86-48738

B

- BAARSPUL, M.**
Flight simulation techniques with emphasis on the generation of high fidelity 6 DOF motion cues
p 839 A86-49024
- BACH, R. E., JR.**
The analysis of airline flight records for winds and performance with application to the Delta 191 accident
[AIAA PAPER 86-2227] p 829 A86-47690
Angle-of-attack estimation for analysis of CAT encounters
p 831 A86-47798
- BACON, B. J.**
A fundamental approach to equivalent systems analysis
[AIAA PAPER 86-2128] p 828 A86-47674
- BADACH, A.**
Performance evaluation of a linear recursive technique for aircraft altitude prediction in airborne collision avoidance systems
p 811 A86-49085
- BADGETT, M. E.**
Robust fault detection and isolation for a high performance aircraft on STOL approach
[AIAA PAPER 86-2031] p 821 A86-47421
- BAILEY, R. E.**
Effect of head-up display dynamics on fighter flying qualities
[AIAA PAPER 86-2206] p 792 A86-47485
- BAILLIE, S.**
The effect of heave damping (ZW) on helicopter handling qualities
[AIAA PAPER 86-2129] p 828 A86-47675
- BAKER, L.**
Comparison of published HEMP and natural lightning on the surface of an aircraft
p 783 A86-47293
- BAKUNIN, V. N.**
An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography
p 844 A86-49964
- BALAKRISHNA, S.**
A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure
[NAL-TRM-SE-8603] p 782 N86-32393
- BANDA, C. P.**
A knowledge-based expert system for scheduling of airborne astronomical observations
p 854 A86-49627
- BANDA, S. S.**
A preliminary investigation of H (infinity) optimization
[AIAA PAPER 86-2197] p 853 A86-47477
- BANERJEE, D.**
Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis
p 799 A86-48667
- BANKHEAD, H. R.**
Subsonic/transonic stall flutter investigation of an advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
- BANSEMER, H.**
Structural design and analysis aspects of composite helicopter components
[MBB-UD-454-85-OE] p 806 A86-50258
- BAR-ITZHACK, I. Y.**
Frequency and time domain designs of a strapdown vertical determination system
[AIAA PAPER 86-2148] p 810 A86-47457
- BARBI, C.**
Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592
- BARDOU, J.**
Anemobarometry: An essential element of flight control
p 835 N86-31566

- BARTOLI, F.**
Model-following control for an oblique-wing aircraft
[AIAA PAPER 86-2244] p 824 A86-47492
- BASTON, A.**
Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044
- BAUM, C. E.**
Comparison of published HEMP and natural lightning on the surface of an aircraft p 783 A86-47293
- BEATON, R. M.**
A methodology for evaluating the operational performance of an aircraft in a tactical environment
[AIAA PAPER 86-2095] p 759 A86-47444
- BEAUFREIRE, H.**
Limitations of statically unstable aircraft due to the effects of sensor noise, turbulence, and structural dynamics
[AIAA PAPER 86-2203] p 824 A86-47483
- BECKER, B.**
Premixing gas and air to reduce NOx emissions with existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211
- BECKER, K.**
Test and flight evaluation of precision distance measuring equipment p 788 A86-49017
- BEHLKE, R. F.**
The use of surface static pressure data as a diagnostic tool in multistage compressor development
[ASME PAPER 86-GT-3] p 812 A86-48103
- BELCASTRO, C. M.**
Evaluation of total energy-rate feedback for glidescope tracking in wind shear
[AIAA PAPER 86-2035] p 822 A86-47424
- BELOV, V. E.**
The drag of a pair of bodies at supersonic flight velocities p 768 A86-48802
- BENDIKSEN, O. O.**
Aeroelastic behavior of low aspect ratio metal and composite blades
[ASME PAPER 86-GT-243] p 846 A86-48271
- BENIGUEL, Y.**
Induced current surface density after a direct lightning strike on an aircraft p 790 A86-47297
- BENNETT, H. W.**
Future trends in propulsion p 816 A86-48979
- BENOIT, A.**
A simulation facility for assessing the next generation of 4-D air traffic control procedures p 788 A86-48034
- BERDAHL, C. H.**
Utilization of computation and experiment for airframe propulsion integration development p 803 A86-49110
- BERENBRINK, P.**
Premixing gas and air to reduce NOx emissions with existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211
- BERLIAND, A. T.**
Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769
- BERRY, D. T.**
Validation of a new flying quality criterion for the landing task
[AIAA PAPER 86-2126] p 828 A86-47672
- BERTELRUD, A.**
Method of analysing data on a swept wing aircraft in flight p 775 A86-49103
- BERTHE, C. J.**
Effects of time delay and pitch control sensitivity in the flared landing
[AIAA PAPER 86-2075] p 831 A86-47706
- BESCH, M.**
Influence of EFCS-control laws on structural design of modern transport aircraft p 800 A86-48984
- BEVILACQUA, L. A.**
Advanced concepts in small helicopter engine air-cooled turbine design p 819 A86-50075
- BHAGAWAN, B. S.**
Six degree of freedom simulation software
[NAL-PD-SE-8614] p 854 N86-33042
- BIANCHINI, J. C.**
Computing codes for development of helicopter crashworthy structures and test substantiation p 798 A86-48657
- BICKNELL, J. A.**
The energy requirements of an aircraft triggered discharge p 844 A86-47315
- BIL, C.**
Applications of computer-aided engineering to subsonic aircraft design in a university environment p 801 A86-48986
- BILLINGSLEY, B.**
Flight testing on customer aircraft with a portable airborne digital data system p 810 A86-47788
- BISHOP, J.**
Aspects of lightning protection schemes for radomes p 792 A86-47338
- BJORKMAN, E. A.**
Flight test evaluation of techniques to predict longitudinal pilot induced oscillations
[AIAA PAPER 86-2253] p 826 A86-47509
- BLACKBURN, A. W.**
Canard canard p 763 A86-49682
- BLAGOVESHCHENSKII, N. A.**
The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843
- BLANCHARD, A.**
Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457
- BLASZCZYK, J.**
Solid-beam model of a deformable aircraft for natural-vibration studies p 804 A86-49444
- BLOM, G.**
PN/S calculations for a fighter W/F at high-lift yaw conditions
[AIAA PAPER 86-1829] p 779 A86-49588
- BLYTHER, A.**
Potential application of advanced propulsion systems to civil aircraft p 802 A86-49093
- BOBER, L. J.**
An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow
[AIAA PAPER 86-0467] p 856 A86-49566
- BOEHM, H.-D. V.**
Applications of thermal imager devices incl. modelling aspects
[MBB-UD-462-85-OE] p 850 A86-50254
- BOES, G.**
Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331
- BOETTCHER, W.**
Aircraft protection against lightning strikes p 806 A86-50347
- BOHON, H. L.**
Composites in today's and tomorrow's U.S. airliners p 841 A86-47603
- BOIS, J.-M.**
Analysis and simulation of the MLS landing signal - Echo separation p 788 A86-48564
- BOISSEAU, J.-F.**
New methods for in-flight vibration testing p 820 A86-47369
- BOITSOV, B. V.**
Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear p 804 A86-49288
- BOLEY, L. E.**
Analytical applications in the Army oil analysis program p 845 A86-47595
- BONNICE, W. F.**
Aircraft control surface failure detection and isolation using the OSGLR test
[AIAA PAPER 86-2028] p 821 A86-47419
- BORCHERS, I.**
New technology propulsion (ANT) for general aviation aircraft, phase 1
[BMFT-FB-W-85-031] p 820 N86-31589
- BORETTI, A.**
Development of an experimental correlation for transonic turbine flow
[ASME PAPER 86-GT-108] p 765 A86-48170
- BOTTEN, L. C.**
Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064
- BOULAY, J. L.**
Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning p 804 A86-49132
- BOWERS, D. L.**
Utilization of computation and experiment for airframe propulsion integration development p 803 A86-49110
- BOYLE, D.**
Secondary radar leads - Monopulse points the way p 787 A86-48372
- BRADSHAW, A.**
Active flutter suppression p 832 A86-49004
- BRADSHAW, W.**
Certification of advanced experimental aircraft p 785 A86-49036
- BRAHNEY, J. H.**
Pumps for 8000 psi hydraulic systems examined p 846 A86-48042
- BRANDNER, H.**
Premixing gas and air to reduce NOx emissions with existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211
- BRANDON, J. M.**
Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control p 833 A86-49039
- BRANSTETTER, J. R.**
Use of flight simulation to develop terminal instrument procedures for transport category aircraft
[AIAA PAPER 86-2072] p 837 A86-47662
- BRESINA, J. J.**
Model-following control for an oblique-wing aircraft
[AIAA PAPER 86-2244] p 824 A86-47492
- BREUSOVA, R. A.**
Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769
- BRICK, R. O.**
Multipath lightning protection for composite structure integral fuel tank design p 790 A86-47308
- BRINES, G. L.**
Heat management in advanced aircraft gas turbine engines
[ASME PAPER 86-GT-76] p 813 A86-48144
- BRINKLEY, J. W.**
Evaluation of a pre-ejection upper torso retraction device p 793 A86-47728
- BRISTOW, J. W.**
Ageing aircraft as seen by an authority p 783 A86-47611
- BROCKHAUS, R.**
Flight path reconstruction - A powerful tool for data compatibility check p 833 A86-49041
- BROOKS, T. F.**
Airfoil trailing-edge flow measurements p 780 A86-49803
- BROOKS, W. G.**
The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001
- BROWN, C. M.**
Analytical applications in the Army oil analysis program p 845 A86-47595
- BROWN, F. S.**
T-46A - The USAF next generation trainer p 796 A86-47796
- BROWN, P. W.**
Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318
- BROWNE, J. T.**
The MIL-prime standard for aircraft flying qualities
[AIAA PAPER 86-2131] p 828 A86-47677
- BRUCE, K. R.**
NASA B737 flight test results of the Total Energy Control System
[AIAA PAPER 86-2143] p 826 A86-47516
- BRUENS, H. D.**
Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295
- BRYANT, W. H.**
Development of a takeoff performance monitoring system
[NASA-TM-89001] p 835 N86-31591
- BRYSN, N. V.**
Determination of the required number of channels for controlling aircraft wing loading for several cases of calculation p 768 A86-48787
- BRYSON, A. E., JR.**
Optimal landing of a helicopter in autorotation
[AIAA PAPER 86-2287] p 793 A86-47705
- BUCHS, W.**
Dynamics of a helicopter with a sling load
[AIAA PAPER 86-2288] p 831 A86-47709
- BUCHS, W.**
Structural design and analysis aspects of composite helicopter components
[MBB-UD-454-85-OE] p 806 A86-50256
- BUERS, H.**
Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782
- BUETEFISCH, K. A.**
Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer p 775 A86-49074
- BURKEN, J. J.**
Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft
[AIAA PAPER 86-2243] p 824 A86-47491
- BURYGIN, O. A.**
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack p 767 A86-48762

- A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842
- BUTLER, T. L.**
Predictions of endwall losses and secondary flows in axial flow turbine cascades
[ASME PAPER 86-GT-228] p 766 A86-48262
- BYERS, J. M.**
Advancements in inertia reels for fixed seating aircraft p 784 A86-47744

C

- CAAP, P.**
Calculation of static elastic effects on a modern high performance fighter aircraft
[AIAA PAPER 86-1771] p 777 A86-49577
- CAGLAYAN, A. K.**
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors
[AIAA PAPER 86-2030] p 810 A86-47511
- CALICO, R. A.**
Flight test evaluation of techniques to predict longitudinal pilot induced oscillations
[AIAA PAPER 86-2253] p 826 A86-47509
- Modelling of rigid-body and elastic aircraft dynamics for flight control development
[AIAA PAPER 86-2232] p 829 A86-47693
- CAMPANELLA, A. J.**
Measurements and computer modelling of engine exhaust noise in the cabin of single-engine aircraft p 798 A86-48594
- CAMPBELL, C. W.**
Recent advances in Monte Carlo turbulence simulation p 792 A86-47636
- CAN, M. H.**
Research on active suppression technology for wing/aileron flutter p 835 A86-49096
- CARBONE, A.**
Control of interior noise in advanced turbopropeller aircraft p 802 A86-49100
- CARCAILLET, R.**
Leading edge vortex flow over a 75 degree-swept delta wing. Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
- CARMICHAEL, R. M.**
Stability and control of aircraft with manual all-moving tailplanes
[AIAA PAPER 86-2231] p 829 A86-47692
- CARON, P.**
Single crystal superalloys for turbine blades in advanced aircraft engines
[ONERA, TP NO. 1986-102] p 843 A86-49077
- CASTEX, A.**
Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592
- CASTONA, T. C.**
A new look at inflight loads on existing transport aircraft p 796 A86-47794
- CAVALLINI, A.**
Stripping and painting a plane - Technological and economic aspects p 760 A86-47614
- CAZIER, F. W., JR.**
Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 N86-31568
- CEBECI, T.**
Calculation of flow over multielement airfoils at high lift p 772 A86-49011
- CERRA, J. J., II**
Modelling of rigid-body and elastic aircraft dynamics for flight control development
[AIAA PAPER 86-2232] p 829 A86-47693
- CHADERJIAN, N. M.**
Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation
[NASA-TM-88248-PT-2] p 782 N86-32392
- CHALK, C. R.**
Effects of time delay and pitch control sensitivity in the flared landing
[AIAA PAPER 86-2075] p 831 A86-47706
- CHAMBERS, J. R.**
High-angle-of-attack aerodynamics - Lessons learned
[AIAA PAPER 86-1774] p 777 A86-49578
- CHAMIS, C. C.**
Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141
- CHANG, K. C.**
Calculation of flow over multielement airfoils at high lift p 772 A86-49011
- CHAUSSÉE, D.**
PN/S calculations for a fighter W/F at high-lift yaw conditions
[AIAA PAPER 86-1829] p 779 A86-49588

- CHAUSSÉE, D. S.**
High speed viscous flow calculations about complex configurations
[NASA-TM-88237] p 850 N86-31827
- CHEN, C.-L.**
Trapping of a free vortex by airfoils with surface suction p 780 A86-49801
- CHEN, P. C.**
Oscillating wings and bodies with flexure in supersonic flow. Applications of harmonic potential panel method p 776 A86-49108
- CHEN, Z. F.**
Research on active suppression technology for wing/aileron flutter p 835 A86-49096
- CHIAO, S.**
Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
- CHMIELEWSKI, G. E.**
Three-dimensional transonic flow computations on simple skewed grids
[AIAA PAPER 86-1794] p 778 A86-49581
- CHOU, J.-G.**
Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
- CHOU, S.-T.**
Broadband noise of propellers and rotors p 855 A86-48596
- CHOW, C.-Y.**
Trapping of a free vortex by airfoils with surface suction p 780 A86-49801
- CHOW, W. K.**
Automated pole placement algorithm for multivariable optimal control synthesis
[AIAA PAPER 86-2196] p 852 A86-47476
- CHOY, F. K.**
Nonlinear dynamics of rotor/blade/casing rub interactions
[ASME PAPER 86-DE-6] p 818 A86-49620
- CHRISTODOULOU, T.**
Reducing fuel consumption by cyclic control p 832 A86-48991
- CHRISTOPHE, J. M.**
The F2 wind tunnel of the Fuga-Mauzac Test Center
[ONERA, TP NO. 1986-104] p 839 A86-49075
- CHU, L.-C.**
Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045
- CHUANG, A.**
Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045
- CLARK, B. J.**
Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller
[AIAA PAPER 86-1893] p 780 A86-49625
- CLARK, R. W.**
Calculation of flow over multielement airfoils at high lift p 772 A86-49011
- CLER, A.**
Theoretical and experimental analysis of separations on helicopter fuselages
[AAAF PAPER NT 85-08] p 766 A86-48458
- CLINE, P. A.**
Airport noise control strategies
[AD-A167977] p 840 N86-31602
- COLE, J. D.**
Transonic wave drag estimation and optimization using the nonlinear area rule
[AIAA PAPER 86-1798] p 778 A86-49582
- COLLINS, D. J.**
Automated pole placement algorithm for multivariable optimal control synthesis
[AIAA PAPER 86-2196] p 852 A86-47476
- Application of eigenstructure assignment to design of robust decoupling controllers in MIMO systems
[AIAA PAPER 86-2246] p 825 A86-47493
- CONDOMINAS, A.**
The A-320 aerodynamics. The turboreactor air inlet
[NOTE-427.021/86] p 806 N86-31567
- CONDOM, P.**
Fighter power for the 1990s p 816 A86-48369
- CONIGLIARO, P.**
F-14A low-altitude asymmetric thrust simulation and flight test program p 795 A86-47785
- CONNOR, T. L.**
Area equivalent method (AEM) on VISICALC and LOTUS 1-2-3 - The Federal Aviation Administration's spreadsheet programs for predicting noise exposure contour areas around an airport p 853 A86-48595
- CONNORS, M. P.**
Evaluation of a pre-ejection upper torso retraction device p 793 A86-47728

- COOK, M. V.**
The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056
- COORENS, J. J.**
Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2
[ETN-86-97395] p 811 N86-31581
- COSTES, M.**
Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows
[ONERA, TP NO. 1986-101] p 776 A86-49106
- COUEDOR, C.**
Identification of unsteady response in rudders at low velocities
[AAAF PAPER NT 85-19] p 797 A86-48468
- COUPRY, G.**
Aeroelasticity today and tomorrow
[ONERA, TP NO. 1986-105] p 800 A86-48978
- COUSTEIX, J.**
Reduction of turbulent drag - Turbulence manipulators
[AAAF PAPER NT 85-04] p 766 A86-48455
- COUSTOLS, E.**
Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing
[AAAF PAPER NT 85-03] p 766 A86-48454
- Reduction of turbulent drag - Turbulence manipulators
[AAAF PAPER NT 85-04] p 766 A86-48455
- CRAIG, D. K.**
The airline engineering role in the management of safety p 762 A86-49084
- CRAWFORD, P. J.**
Managing airworthiness p 785 A86-49035
- CRAWLEY, E. F.**
Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan
[ASME PAPER 86-GT-98] p 813 A86-48163
- CREDEUR, L.**
Advanced ATC - An aircraft perspective p 788 A86-49637
- CROCKER, M. J.**
The effect on the transmission loss of a double wall panel of using helium gas in the gap p 855 A86-48590
- Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738
- CROSS, A. G. T.**
Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031
- CRUES, Z.**
An explicit adaptive flight control system based on the modified gain extended Kalman filter
[AIAA PAPER 86-2158] p 823 A86-47465
- CURTISS, H. C., JR.**
The dynamic response of helicopters to fixed wing aircraft wake encounters p 832 A86-48671
- CUTLER, W.**
X-29 Technology Demonstrator program status review p 796 A86-47795
- CYRUS, J. D.**
Engine component life prediction methodology for conceptual design investigations
[ASME PAPER 86-GT-24] p 812 A86-48116

D

- DAHL, G.**
Digital engine control units for an fighter engine and an auxiliary power unit - A comparison p 817 A86-49089
- DAI, H.**
Numerical analysis of aeroelastic stability problem of helicopter rotor blade p 798 A86-48662
- DALAN, G. A.**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573
- DAMICO, W. P., JR.**
Parametric study of low Reynolds number precessing/spinning incompressible flows
[AIAA PAPER 86-2027] p 827 A86-47661
- DARTEYRE, G.**
Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 760 A86-47609
- DASH, S. M.**
Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804

- DAVIDSON, J. B.**
Flight control synthesis for flexible aircraft using Eigenspace assignment
[NASA-CR-178164] p 835 N86-31590
- DAVIES, W. J.**
Engine control reliability and durability improvement through accelerated mission environmental testing
[ASME PAPER 86-GT-52] p 813 A86-48132
- DAVIS, B. S.**
Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660
- DAVIS, D. J.**
Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2
[NASA-CR-4014] p 836 N86-32440
- DAVIS, R. A.**
747 modernization p 800 A86-48985
- DEBBELER, F. J.**
Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121
- DEHM, S.**
On the fast repair of aircraft panel components p 762 A86-49066
- DEJONGE, J. B.**
Review of aeronautical fatigue investigations in the Netherlands during the period March 1983 - February 1985
[NLR-MP-85025-U] p 851 N86-32779
- DELOACH, R.**
Pilot evaluation of experimental flight trajectories in the near-terminal area
[AIAA PAPER 86-2074] p 838 A86-47664
- DEMEIS, R.**
Sounding a happy note for lift p 780 A86-49676
Wind tunnels battle the number-crunchers p 840 A86-49683
- DESMARIS, L. A.**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants
[AD-A167444] p 807 N86-31572
- DESTUYNDER, R.**
New methods for in-flight vibration testing p 820 A86-47369
- DEWOLF, W. B.**
Recent developments in propulsion aerodynamics
[NLR-MP-85031-U] p 820 N86-32437
- DIETZ, D. C.**
An analytical methodology for predicting repair time distributions of advanced technology aircraft
[AD-A167149] p 763 N86-31529
- DIGNEY, J. R.**
Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method p 839 A86-49060
- DILLARD, M. W.**
Fireproof hydraulic brake system
[AD-A167774] p 786 N86-31549
- DINYAVARI, M. A. H.**
Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis p 799 A86-48667
- DOBRYNSKI, W. M.**
Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061
- DOR, J. B.**
Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457
- DORR, D. W.**
Rotary-wing aircraft terrain-following/terrain-avoidance system development
[AIAA PAPER 86-2147] p 823 A86-47456
- DOVGAL, A. V.**
Method for the visualization of subsonic gas flows p 769 A86-48808
- DOWNING, D. R.**
Sensitivity analysis of high-order digital flight control systems using singular-value concepts
[AIAA PAPER 86-2084] p 822 A86-47437
Development of a takeoff performance monitoring system
[NASA-TM-89001] p 835 N86-31591
- DREXLER, J.**
A contribution to airworthiness certification of gas turbine disks p 849 A86-49136
- DRIVER, C.**
The impact of emerging technologies on an advanced supersonic transport p 761 A86-48997

- DROBIK, J. S.**
Stability and control of aircraft with manual all-moving tailplanes
[AIAA PAPER 86-2231] p 829 A86-47692
- DUCHARME, E. H.**
Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan
[ASME PAPER 86-GT-98] p 813 A86-48163
- DUFFY, K. S.**
Boeing control law for CREST demonstration ejection seat p 794 A86-47758
- DUNHAM, J.**
The role of flow field computation in improving turbomachinery p 775 A86-49080
- DUNKLEY, V. P.**
The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306
- DURAND, G.**
Unsteady aerodynamics - Fundamental aspects and applications to aircraft dynamics
[AAAF PAPER NT 85-16] p 767 A86-48465
- DUROURE, C.**
Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299
- DWYER, R. F.**
Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems
[AD-A167400] p 856 N86-32249
- DZVONIK, L. I.**
The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174

E

- ECKARDT, D.**
Propfan and turbofan - Antagonism or synthesis p 817 A86-49092
- EDWARDS, A. C.**
Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model p 796 A86-47800
- EDWARDS, J. A.**
Some aspects of supersonic flow over a cavity cascade
[AIAA PAPER 86-2025] p 764 A86-47659
- EDWARDS, J. W.**
Applications of potential theory computations to transonic aeroelasticity p 775 A86-49105
- EGGLESTON, B.**
Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
- EISLER, G. R.**
Optimal descending, hypersonic turn to heading
[AIAA PAPER 86-2134] p 841 A86-47679
- EL-AINI, Y. M.**
Subsonic/transonic stall flutter investigation of an advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
- ELASKAR, J. F.**
Wind influence on the range of jet or propeller aircraft p 801 A86-48990
- ELEMELAND, L.**
Calculation of static elastic effects on a modern high performance fighter aircraft
[AIAA PAPER 86-1771] p 777 A86-49577
- ELFEKI, S.**
Particulate flow solutions through centrifugal impeller with two splitters
[ASME PAPER 86-GT-130] p 765 A86-48188
- ELGUDINA, B. A.**
The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843
- ENSIGN, C. R.**
Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads
[ASME PAPER 86-GT-172] p 815 A86-48224
- ENTZ, D. P.**
Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2
[NASA-CR-4014] p 836 N86-32440
- ER-EL, J.**
Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046
- ERB, R. E.**
Use of hinged strakes for lateral control at high angles of attack
[AIAA PAPER 86-2278] p 830 A86-47696

- ERICKSON, L. L.**
Application of the TranAir full-potential code to complete configurations p 772 A86-49009
- ERICSSON, L. E.**
Vortex-induced effects on aircraft dynamics
[AIAA PAPER 86-2279] p 830 A86-47697
- ERKELENS, L. J. J.**
Flight simulation of MLS interception procedures applicable to laterally segmented approach paths
[AIAA PAPER 86-2073] p 837 A86-47663
- ESLINGER, R. A.**
Control reconfigurable combat aircraft flight control system development
[AIAA PAPER 86-2236] p 824 A86-47488
- ETERNO, J. S.**
Simulation results of automatic restructurable flight control system concepts
[AIAA PAPER 86-2032] p 821 A86-47422
- EVANS, W. J.**
TURBISTAN: A standard load sequence for aircraft engine disks
[NLR-MP-85033-U] p 820 N86-32436
- EVERSMAN, W.**
Modelling of acoustic radiation problems associated with turbomachinery and rotating blades p 855 A86-48597

F

- FABUNMI, J. A.**
Developments in helicopter ground vibration testing p 805 A86-49638
- FAGOT, H.**
Interferometric holographic cinematography
[ISL-CO-219/85] p 851 N86-31872
- FALTUS, M.**
Design of a nonlinear lever-type mechanism for aircraft control systems p 835 A86-49139
- FARM, J. A.**
Design of a multivariable flutter control/gust load alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494
- FARRIS, R. L.**
Advancements in inertia reels for fixed seating aircraft p 784 A86-47744
- FAULKNER, A.**
Handling qualities and flight performance - Implication of the operational envelope p 799 A86-48672
- FAVIER, D.**
Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592
- FELT, L. R.**
Flight flutter testing at Ames-Dryden p 797 A86-47802
- FFOWCS WILLIAMS, J. E.**
The aerodynamic potential of anti-sound p 855 A86-48977
- FIALA, J.**
Experience with stress analysis during airframe fatigue tests p 840 A86-49143
- FICHTL, G. H.**
Recent advances in Monte Carlo turbulence simulation p 792 A86-47636
- FINELLI, G. B.**
F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259
- FISCHER, H. W.**
Studies for the application of a flexible weight and balance (W/B) measuring facility for commercial aircraft [BMFT-FB-W-85-029] p 840 N86-31604
- FISHER, B. D.**
Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318
- FLEETER, S.**
Splitter blades as an aeroelastic detuning mechanism for unstalled supersonic flutter of turbomachine rotors
[ASME PAPER 86-GT-99] p 813 A86-48164
- FLOYD, M. A.**
MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation
[AIAA PAPER 86-2085] p 853 A86-47505
- FORESTER, C. K.**
CFD for engine-airframe integration
[ASME PAPER 86-GT-125] p 797 A86-48184
- FORM, P.**
Performance evaluation of a linear recursive technique for aircraft altitude prediction in airborne collision avoidance systems p 811 A86-49085
- FOTTNER, L.**
Evaluation of the blade-to-blade flow from a high speed compressor rotor
[ASME PAPER 86-GT-117] p 765 A86-48176

- FRASSINELLI, M. C.**
Low-speed aerodynamics of apex fences on a tailless delta configuration
[AIAA PAPER 86-1838] p 779 A86-49583
- FREIER, G. D.**
Optical detection methods for testing of fuel tank lightning ignition hazards p 791 A86-47309
- FRISCH, G. D.**
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738
- FRITSVOLD, J. D.**
The risk of collision in a two seat aircraft ejection p 783 A86-47730
- FROLOV, V. M.**
Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845
- FROUSTEY, C.**
Fatigue resistance of high quality steels under multiaxial load
[ETN-86-97878] p 851 N86-32785
- FUJII, K.**
Navier-Stokes simulation of transonic flow over wing-fuselage combinations
[AIAA PAPER 86-1831] p 779 A86-49589
- FUJIWARA, T.**
Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model p 776 A86-49245
- FULLER, C. R.**
Noise control characteristics of synchrophasing. II - Experimental investigation p 805 A86-49808
- FUN, W.-P.**
An explicit adaptive flight control system based on the modified gain extended Kalman filter
[AIAA PAPER 86-2158] p 823 A86-47465
- G**
- GAIFULLIN, A. M.**
Flow of an ideal fluid in the core of a vortex sheet p 770 A86-48839
- GALBRAITH, R. A. MCD.**
On the duration of low speed dynamic stall p 773 A86-49033
- GALDA, K. H.**
Early corrosion detection and prevention measures p 760 A86-47612
- GALMICHE, P.**
The M53 turbofan control system - A strong basis for the development of the future digital control systems p 817 A86-49088
- GAMON, M. A.**
KRASH 85 user's guide: Input/output format, revision
[AD-A168846] p 787 N86-32416
- GANY, A.**
Theoretical considerations of the specific impulse of ramjet engines p 817 A86-49111
- GAO, Z.**
A study of the rotor wake in nap-of-the-earth p 767 A86-48653
- GARCIA-FOGEDA, P.**
Oscillating wings and bodies with flexure in supersonic flow Applications of harmonic potential panel method p 776 A86-49108
- GARDINER, B.**
Field observations of aircraft charging in convective clouds p 783 A86-47332
- GARDNER, R. L.**
Comparison of published HEMP and natural lightning on the surface of an aircraft p 783 A86-47293
- GARG, S.**
Cooperative synthesis of control and display augmentation
[AIAA PAPER 86-2204] p 853 A86-47484
- GARRARD, W. L.**
Design of a multivariable flutter control/gust load alleviation system
[AIAA PAPER 86-2247] p 825 A86-47494
- GAUGH, W. J.**
Single-state observer design considerations for aircraft application
[AIAA PAPER 86-1996] p 852 A86-47418
- GAVITO, V. F.**
Application of eigenstructure assignment to design of robust decoupling controllers in MIMO systems
[AIAA PAPER 86-2246] p 825 A86-47493
- GAYET, J. F.**
Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299
- GEORGE, A. R.**
Broadband noise of propellers and rotors p 855 A86-48596

- GEVARTER, W. B.**
A knowledge-based expert system for scheduling of airborne astronomical observations p 854 A86-49627
- GIBSON, J. C.**
Handling qualities for unstable combat aircraft p 833 A86-49025
- GIBSON, K. J.**
An improved optical viewing system for a flight simulator
[MS-9025] p 840 N86-32448
- GIBSON, M. W.**
Avionics digital data acquisition system p 810 A86-47790
- GIELEN, H.**
Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121
- GILBERT, J. L.**
Comparison of published HEMP and natural lightning on the surface of an aircraft p 783 A86-47293
- GILBERT, M. G.**
Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- GILLESPIE, G.**
Emergency underwater escape from helicopters p 784 A86-47745
- GILMAN, R. J.**
Survivability considerations during aircraft conceptual design
[AD-A168555] p 809 N86-32428
- GILMORE, J. F.**
Experts system control of autonomous airborne vehicle p 835 A86-49476
- GILSON, C.**
Fighter power for the 1990s p 816 A86-48369
- GILYARD, G. B.**
Eigenstructure synthesis for active flutter suppression on an oblique-wing aircraft
[AIAA PAPER 86-2243] p 824 A86-47491
- GILSON, C.**
Real-time flutter identification with close mode resolution
[AIAA PAPER 86-2019] p 827 A86-47654
- GIRAUD, M.**
Power level influence on architecture of small helicopter turboshaft engines
[ASME PAPER 86-GT-191] p 815 A86-48241
- GODIOWALA, P. M.**
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors
[AIAA PAPER 86-2030] p 810 A86-47511
- GOERANSSON, P.**
A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340
[FFA-TN-1986-22] p 856 N86-33125
- GOMAN, M. G.**
Self-oscillatory regimes of aircraft motion during spin-roll coupling p 832 A86-48775
- GONCHAR, A. G.**
Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838
- GONCHARENKO, V. I.**
A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842
- GONCHARENKO, V. I.**
A certain type of self-oscillation of aircraft landing-gear wheels p 800 A86-48829
- GOODYKOONTZ, J. H.**
Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust
[AIAA PAPER 86-1809] p 778 A86-49585
- GOORJIAN, P. M.**
ATRAN3S: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535
- GORADIA, S.**
A new, improved method for separating turbulent boundary layer for aerodynamic performance prediction of trailing edge stall airfoils
[AIAA PAPER 86-1832] p 779 A86-49590
- GOSTELOW, J. P.**
Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064
- GOTO, N.**
Identification of pilot dynamics in a system with a choice of feedback structures
[AIAA PAPER 86-2250] p 825 A86-47496
- GOUNET, H.**
Prediction of single-rotation prop-fan noise by a frequency domain scheme
[ONERA, TP NO. 1986-100] p 818 A86-49125
- GOUNET, H.**
Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA
[ONERA-RT-19/3463-AYP] p 841 N86-32451

- GOVINDARAJ, K. S.**
Six degree of freedom simulation software
[NAL-PD-SE-8614] p 854 N86-33042
- GRANTHAM, W.**
The interpretation of flying qualities requirements for flight control design
[AIAA PAPER 86-2249] p 826 A86-47523
- GRANTHAM, W.**
Effects of time delay and pitch control sensitivity in the flared landing
[AIAA PAPER 86-2075] p 831 A86-47706
- GRAVELLE, A.**
Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows
[ONERA, TP NO. 1986-101] p 776 A86-49108
- GRAY, D. E.**
Heat management in advanced aircraft gas turbine engines
[ASME PAPER 86-GT-76] p 813 A86-48144
- GREEN, I.**
A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340
[FFA-TN-1986-22] p 856 N86-33125
- GREEN, J. A.**
Aeroelastic tailoring of aft-swept high aspect ratio composite wings p 802 A86-49097
- GREEN, K. C.**
On the handling qualities of flight vehicles through variable flight conditions
[AD-A167727] p 836 N86-31592
- GREINICH, A. F.**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies
[AD-A167356] p 807 N86-31570
- GREINICH, A. F.**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary
[AD-A167443] p 807 N86-31571
- GRIEB, H.**
Propan and turbofan - Antagonism or synthesis p 817 A86-49082
- GRIGAT, J.**
A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations
[ESA-TT-928] p 789 N86-31558
- GRISHIN, V. I.**
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48846
- GRORUD, E.**
Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296
- GROSS, H. N.**
Control reconfigurable combat aircraft flight control system development
[AIAA PAPER 86-2236] p 824 A86-47488
- GROUAS, J.**
Dynamic response of the A.310 in flight to control-surface loading
[AAAF PAPER NT 85-18] p 797 A86-48467
- GRUNWALD, A.**
Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms
[AIAA PAPER 86-2248] p 825 A86-47495
- GU, Z. Q.**
Research on active suppression technology for wing/aileron flutter p 835 A86-49096
- GUELDER, O. E. L.**
Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels
[ASME PAPER 86-GT-163] p 843 A86-48216
- GURUSWAMY, G. P.**
ATRAN3S: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535
- GUSTAVSSON, A. I.**
Measurements of landing gear loads of a commuter airliner p 803 A86-49119
- GUYOT, G.**
Airbus A 320 - New concept of aircraft control p 796 A86-47797
- H**
- HABERLAND, C.**
On the computation of wing lift interference caused by high bypass engines p 776 A86-49109
- HADAD, D. K.**
Chemical analysis for control p 842 A86-47720
- HADY, W. F.**
Stratified charge rotary engine for general aviation
[ASME PAPER 86-GT-181] p 815 A86-48231

HAFEZ, M. M.

An entropy correction method for unsteady full potential flows with strong shocks
[AIAA PAPER 86-1788] p 777 A86-49576

HAFTMANN, B.

Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121

HAGEMAIER, D. J.

Supplemental inspections of aging aircraft p 845 A86-47525

HAHN, K.-U.

Take-off and landing in a downburst p 786 A86-49069

HAIGES, K. R.

Robust fault detection and isolation for a high performance aircraft on STOL approach
[AIAA PAPER 86-2031] p 821 A86-47421

HAINES, R. F.

Simulator scene display evaluation device
[NASA-CASE-ARC-11504-1] p 840 N86-32447

HALL, C. K.

Materials in aerospace - Can the emerging thermoplastics meet the challenge? p 843 A86-49020

HALL, S. R.

Aircraft control surface failure detection and isolation using the OSGLR test
[AIAA PAPER 86-2028] p 821 A86-47419

HALLETT, J.

Field observations of aircraft charging in convective clouds p 783 A86-47332

HALSEY, N. D.

Calculation of flow over multielement airfoils at high lift p 772 A86-49011

HAN-SENG, L.

Experimental investigation of electrostatic fire and explosion accidents after aircraft landing and preventive design p 786 A86-49083

HANDELMAN, D. A.

A theory for fault-tolerant flight control combining expert system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442

HARDWICK, C. J.

The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306

HARDY, G. H.

Flight evaluation of a precision landing task for a powered-lift STOL aircraft
[AIAA PAPER 86-2130] p 828 A86-47676

HARGRAVES, C. R.

Direct trajectory optimization using nonlinear programming and collocation
[AIAA PAPER 86-2000] p 841 A86-47902

HARMON, M. B.

Supplemental inspections of aging aircraft p 845 A86-47525

HART-SMITH, L. J.

Structural analysis of adhesive-bonded joints p 846 A86-47722

HART, R. E.

Re-engine KC-135R/CFM56 flight test program - An overview p 795 A86-47793

HARTWICH, P.-M.

Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258

HASHIMOTO, T.

Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507

HATTINGH, H. V.

A comparison of pod and tail mounted ramjets p 818 A86-49112

HATTORI, T.

Optimum design technique for rotating wheels
[ASME PAPER 86-GT-255] p 846 A86-48281

HAYDUK, R. J.

Structural dynamics research in a full-scale transport aircraft crash test p 785 A86-49053

HE, C.

A study of the rotor wake in nap-of-the-earth p 767 A86-48653

HEBERT, J. L.

Design of a fast risetime lightning generator p 837 A86-47304

Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307

HEBSCH, F.

On control concept for in-flight simulation including actuator nonlinearities and time delays
[ESA-TT-948] p 836 N86-31593

HEFELE, R.

Comparison of methods for lifetime calculations of highly loaded aero-engine discs
[ASME PAPER 86-GT-102] p 814 A86-48165

HEFFLEY, R. K.

Terminal control factors for the carrier landing task
[AIAA PAPER 86-2251] p 825 A86-47497

HEFNER, J. N.

Laminar flow research applicable to subsonic aircraft p 781 A86-50269

HEIDELBERG, L. J.

Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller
[AIAA PAPER 86-1893] p 780 A86-49625

HEITMAN, K. E.

Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738

HELIN, H. E.

Visualization of dynamic stall controlled by large amplitude interrupted pitching motions
[AIAA PAPER 86-2281] p 764 A86-47699

Control of wake structure behind an oscillating airfoil
[AIAA PAPER 86-2282] p 764 A86-47700

HELLER, H. H.

Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061

HEPNER, D. J.

Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660

HERBST, M. K.

Aerial refueling evaluation of the CH-47D helicopter
[AD-A167575] p 808 N86-31574

HERTZ, T. J.

The development of aeroelastic tailoring in the United States p 805 A86-50111

HESS, J. L.

Time-averaged subsonic propeller flowfield calculations
[AIAA PAPER 86-1807] p 778 A86-49584

HESS, R.

Implications associated with the operation of digital data processing in the presence of the relatively harsh EMP environments produced by lightning p 809 A86-47319

HEYDARI, F.

The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056

HILDEBRAND, J. R.

Multiple thermocouple testing device
[AD-D012276] p 850 N86-31880

HINDSON, W. S.

Optimal landing of a helicopter in autorotation
[AIAA PAPER 86-2287] p 793 A86-47705

Dynamics of a helicopter with a sling load
[AIAA PAPER 86-2288] p 831 A86-47709

HIRAYAMA, N.

A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method
[ASME PAPER 86-GT-111] p 765 A86-48173

HITCH, H. P. Y.

Active control technology for civil transport p 832 A86-49005

HODR, J.

Experience with stress analysis during airframe fatigue tests p 840 A86-49143

HOFER, B.

Fibre optic damage detection in composite structures p 848 A86-48988

HOFFLER, K. D.

Low-speed aerodynamics of apex fences on a tailless delta configuration
[AIAA PAPER 86-1838] p 779 A86-49593

HOH, R.

The effect of heave damping (ZW) on helicopter handling qualities
[AIAA PAPER 86-2129] p 828 A86-47675

HOLDAWAY, D.

High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738

HOLDEMAN, J. D.

Perspectives on dilution jet mixing
[AIAA PAPER 86-1611] p 818 A86-49614

HOLLAND, M. J.

Advances in turbine technology p 817 A86-49079

HOLMES, B. J.

Boundary-layer transition effects on airplane stability and control
[AIAA PAPER 86-2229] p 831 A86-47708

Wing laminar boundary layer in the presence of a propeller slipstream p 776 A86-49122

HOLT, S. H.

Flight testing of general electric high bypass engines evolution and revolution p 812 A86-47786

HOPP, T. H.

A controller for robust asymptotic tracking in systems with time-varying uncertainties
[AIAA PAPER 86-2199] p 853 A86-47479

HORI, N.

Synthesis of an adaptive flight controller under unknown deterministic disturbances
[AIAA PAPER 86-2157] p 823 A86-47464

HORLEBEIN, A.

Development of the BO 105 LS
[MBB-UD-456-85-OE] p 805 A86-50255

HORN, W. J.

Weight estimation techniques for composite airplanes in general aviation industry
[NASA-CR-178163] p 781 N86-31531

HOROWITZ, S. J.

An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806

HORSTMANN, K. H.

Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983

HORTON, H. P.

An experimental study of turbulent wake/boundary layer mixing flows p 772 A86-49014

HORTON, R. E.

Adhesive-bonded aluminum structure repair p 846 A86-47725

HORTON, T. W.

Flight test experience and controlled impact of a large, four-engine remotely piloted airplane p 794 A86-47781

HOUCK, J. A.

Use of flight simulation to develop terminal instrument procedures for transport category aircraft
[AIAA PAPER 86-2072] p 837 A86-47662

Pilot evaluation of experimental flight trajectories in the near-terminal area
[AIAA PAPER 86-2074] p 838 A86-47664

HOUNJET, M. H. L.

Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches
[AIAA PAPER 86-1821] p 778 A86-49586

HOUTCHENS, S. P.

RT-BUILD - Automatic generation of Ada code for flight control applications
[AIAA PAPER 86-2088] p 852 A86-47439

HOUWINK, R.

Computations of separated subsonic and transonic flow about airfoils in unsteady motion
[NLR-MP-84094-U] p 782 N86-31541

HOWARD, R. M.

Wing laminar boundary layer in the presence of a propeller slipstream p 776 A86-49122

HOWELL, G. P.

Truncated Taylor series solutions to a generalized Burgers' equation p 856 A86-49716

HOWELL, W. E.

Advanced ATC - An aircraft perspective p 788 A86-49637

HOWLETT, J. J.

Ground based helicopter simulation p 838 A86-48673

HSU, C.-H.

Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258

HUA, Y.

Numerical solution of transonic stream function equation on S1 stream surface in cascade
[ASME PAPER 86-GT-110] p 765 A86-48172

HUANG, M.-K.

Trapping of a free vortex by airfoils with surface suction p 780 A86-49801

HUBER, H.

Dynamic aspects in the design of advanced rotor systems p 798 A86-48663

HUBERT, J. A.

Development of a controllable catapult for ejection seats p 793 A86-47733

Concept development of a canopy escape module p 784 A86-47759

HUBLEY, K. J.

Quantifying a propeller/engine power response rate mismatch p 796 A86-47801

HULL, D. G.

Optimal descending, hypersonic turn to heading
[AIAA PAPER 86-2134] p 841 A86-47679

HUMES, R. L.

In-flight photogrammetric measurement of wing ice accretions
[NASA-TM-87191] p 806 N86-31562

HUNTER, D. T.

Evaluation of damage tolerance requirements using a probabilistic-based life approach
[ASME PAPER 86-GT-266] p 847 A86-48288

- HUOT, J. P.**
The effect of a downstream rotor on the measured performance of a transonic turbine nozzle
[ASME PAPER 86-GT-103] p 814 A86-48166
- MURRASS, K. H.**
Test and flight evaluation of precision distance measuring equipment p 788 A86-49017
- HUTH, B. P.**
System design and integration of the large-scale advanced prop-fan
[NASA-CR-174789] p 781 N86-31536
- HUTZLER, B.**
High voltage laboratory tests and lightning phenomena p 844 A86-47312
- IAREMCHUK, I. U. F.**
Modeling the elasticity of a wing structure p 800 A86-48850
- INNIS, R. C.**
Flight evaluation of a precision landing task for a powered-lift STOL aircraft
[AIAA PAPER 86-2130] p 828 A86-47876
- IRAKLIONOV, V. S.**
Method for calculating pressure distribution on the surfaces of wings with slit mechanization p 768 A86-48806
- ITOH, T.**
A study on NOx emissions from gas turbine combustor
[ASME PAPER 86-GT-168] p 814 A86-48220
- JAENSSON, B.**
The control and use of residual stresses in aircraft structural parts p 849 A86-49114
- JARMARK, B.**
Near-optimal feedback control for three-dimensional interceptions p 854 A86-48992
- JARRETT, J. S.**
An all-weather multimode landing system for tactical fighter aircraft
[AIAA PAPER 86-2148] p 787 A86-47517
- JELLITI, M.**
Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing
[AAAF PAPER NT 85-03] p 766 A86-48454
- JOHNS, R. H.**
Computational engine structural analysis
[ASME PAPER 86-GT-70] p 813 A86-48141
- JOHNSON, A. M.**
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies
[AD-A167356] p 807 N86-31570
- JOHNSON, D. A.**
Transonic airfoil calculations including wind tunnel wall-interference effects p 780 A86-49825
- JOHNSON, E. T.**
Developments in new gas turbine engine demonstrator programs
[ASME PAPER 86-GT-80] p 813 A86-48148
- JOHNSON, W.**
Recent developments in rotary-wing aerodynamic theory p 780 A86-49802
- JOHNSTON, L. J.**
An experimental study of turbulent wake/boundary layer mixing flows p 772 A86-49014
- JONAS, K.**
New technology propulsion (ANT) for general aviation aircraft, phase 1
[BMFT-FB-W-85-031] p 820 N86-31589
- JONES, D. J.**
Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
- JONES, J. D.**
Noise control characteristics of synchrophasing. II - Experimental investigation p 805 A86-49808
- JOSIFOVIC, M. J.**
Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading p 848 A86-49040
- K**
- KADER, A. A.**
A stochastic decentralized flight control system
[AIAA PAPER 86-1994] p 821 A86-47416
- KAHANEK, V.**
Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137
- KALVISTE, J.**
Spherical mapping and analysis of aircraft angles for maneuvering flight
[AIAA PAPER 86-2283] p 830 A86-47701
- KAMIN, R. A.**
Impact of higher freeze point fuels on naval aircraft operations
[ASME PAPER 86-GT-262] p 843 A86-48285
- KANAI, K.**
Synthesis of an adaptive flight controller under unknown deterministic disturbances
[AIAA PAPER 86-2157] p 823 A86-47464
- KANDEBO, S. W.**
Manufacturers seek reduced costs through new fabrication techniques p 762 A86-49448
- KANDIL, O. A.**
Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045
- KAPPLER, G.**
Comparison of methods for lifetime calculations of highly loaded aero-engine discs
[ASME PAPER 86-GT-102] p 814 A86-48165
- KARPOVICH, P. A.**
Thermal stability concerns of Navy aviation fuel
[ASME PAPER 86-GT-94] p 842 A86-48159
- KASEMIR, H. W.**
Ranging and azimuthal problems of an airborne crossed loop used as a single-station lightning locator p 809 A86-47325
- KATZ, J.**
Unsteady low-speed aerodynamic model for complete aircraft configurations
[AIAA PAPER 86-2180] p 829 A86-47683
- KEEN, J. M.**
Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043
- KEHOE, M. W.**
Flight flutter testing at Ames-Dryden p 797 A86-47802
- KELDYSH, V. V.**
Flight test of passive wing/store flutter suppression
[NASA-TM-87766] p 806 N86-31568
- KELDYSH, V. V.**
Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769
- KELLY, J. R.**
NASA B737 flight test results of the Total Energy Control System
[AIAA PAPER 86-2143] p 826 A86-47516
- KEMPEL, R. W.**
Model-following control for an oblique-wing aircraft
[AIAA PAPER 86-2244] p 824 A86-47492
- KENDALL, T. M.**
Flight test experience and controlled impact of a large, four-engine remotely piloted airplane p 794 A86-47781
- KENDALL, T. M.**
Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660
- KENNETT, M. J.**
The development of a fibre optic data bus for helicopters p 811 A86-49131
- KERR, R. I.**
Automated structural optimisation at Warton p 854 A86-48987
- KHALID, M.**
Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
- KHAN, T.**
Single crystal superalloys for turbine blades in advanced aircraft engines
[ONERA, TP NO. 1986-102] p 843 A86-49077
- KHLEBNIKOV, V. S.**
The drag of a pair of bodies at supersonic flight velocities p 768 A86-48802
- KHOLOSTOVA, G. G.**
An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography p 844 A86-49964
- KHRABROV, A. N.**
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack p 767 A86-48762
- KHOLOSTOVA, G. G.**
Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme p 769 A86-48822
- KHOLOSTOVA, G. G.**
Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838
- KIBENS, V.**
Passive control of jets with indeterminate origins p 780 A86-49807
- KIERS, R. F. C.**
On the way to extended noise reductions in propeller aircraft
[B8573697] p 857 N86-33126
- KILMER, F. G.**
Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779] p 789 N86-31551
- KILMER, R. L.**
Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779] p 789 N86-31551
- KIMURA, H.**
Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507
- KING, C.**
Lightning-induced transient test on a transport aircraft p 791 A86-47327
- KING, L. S.**
Transonic airfoil calculations including wind tunnel wall-interference effects p 780 A86-49825
- KINNEY, C.**
A study of helicopter main rotor noise in hover
[AIAA PAPER 86-1858] p 856 A86-49575
- KISLENKO, A. S.**
The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963
- KITAPLIOGLU, C.**
A study of helicopter main rotor noise in hover
[AIAA PAPER 86-1858] p 856 A86-49575
- KJELGAARD, S. O.**
Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg
[AIAA PAPER 86-1775] p 777 A86-49579
- KLASSEN, D. D.**
Developments in new gas turbine engine demonstrator programs
[ASME PAPER 86-GT-80] p 813 A86-48148
- KLEIN, V.**
Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057
- KNOTTS, L. H.**
Turbulence response matching in the NT-33A in-flight simulator
[AIAA PAPER 86-2076] p 827 A86-47665
- KOBAYAKAWA, M.**
Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
- KOBELEV, V. V.**
Divergence of an anisotropic sweptforward wing p 768 A86-48788
- KOCI, R.**
Application of strain gauge amplifiers and computer technology to the strength testing of aircraft p 849 A86-49144
- KOCKA, V.**
Validation on nonstationary aerodynamics models for longitudinal aeroplane motion on the basis of flight measurements p 833 A86-49026
- KOESTER, H.**
Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983
- KOGAN, M. N.**
Similarity criteria for a circulation control airfoil p 769 A86-48815
- KOLESHNIKOV, A. V.**
Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
- KONG, Z.-K.**
Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer
[ASME PAPER 86-GT-174] p 815 A86-48225
- KOROMZAY, T.**
Quality assurance in the reconditioning of gas turbine and compressor blading components
[ASME PAPER 86-GT-299] p 847 A86-48311
- KOSHORST, J.**
How one A/C manufacturer transits to composites p 759 A86-47604
- KOSORUKOV, A. L.**
Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783
- KOSORUKOV, A. L.**
The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps p 771 A86-48849
- KOSYKH, A. P.**
The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843
- KOZLOV, V. V.**
Method for the visualization of subsonic gas flows p 769 A86-48808
- KRAFT, E. M.**
Advances at AEDC in treating transonic wind tunnel wall interference p 839 A86-49058
- KRIECHBAUM, G.**
Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577

- KRISPIN, J.**
Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049
- KROH, G.**
Anthropometric conditions for the construction of a helicopter cockpit p 794 A86-47768
- KROJER, H.**
New technology propulsion (ANT) for general aviation aircraft, phase 1 [BMFT-FB-W-85-031] p 820 N86-31589
- KRYLOV, I. F.**
The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963
- KUCERA, E.**
Contactless measurement of the torque of an aircraft engine p 849 A86-49145
- KUDRIASHOV, A. B.**
Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830
- KUKINOV, A. G.**
The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation p 816 A86-48757
- KUO, S. C.**
Fabrication of high-alumina ceramic fixtures for jet engine repair applications [ASME PAPER 86-GT-46] p 846 A86-48130
- KUPERMAN, M. H.**
Adhesive-bonded aluminum structure repair p 846 A86-47725
- KUTINOV, V. F.**
Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830
- KUZMIN, V. P.**
Determination of the statistical characteristics of aircraft motion during an automatic approach p 832 A86-48844
- L**
- LABARGE, B. L.**
KRASH 85 user's guide: Input/output format, revision [AD-A168846] p 787 N86-32416
- LACHAUD, B.**
Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners) [SNIAS-436.021/85] p 851 N86-32784
- LAMBERT, M.**
Can Europe meet the challenge of LHX? p 797 A86-48370
- LAMBOURION, J.**
Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA [ONERA-RT-19/3463-AYP] p 841 N86-32451
- LANCASTER, R.**
Evaluation of alternatives for an Army precision landing system [AD-A167780] p 789 N86-31554
- LANDGREBE, A. J.**
Overview of helicopter wake and airloads technology p 767 A86-48654
- LANDY, R. J.**
Development of HIDEAD adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278
- LANG, J.**
Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782
- LANGE, R. H.**
A review of unconventional aircraft design concepts p 801 A86-48995
- LAPLACA, B. J.**
Precise control surface position measurements for hysteresis and twist testing p 795 A86-47789
- LAROCHE, P.**
Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299
- LARSON, R. R.**
Flight control system development and flight test experience with the F-111 mission adaptive wing aircraft [AIAA PAPER 86-2237] p 824 A86-47489
- LARSSON, S.-E.**
The control and use of residual stresses in aircraft structural parts p 849 A86-49114
- LASCHKA, B.**
Design of a supercritical airfoil p 771 A86-48982
- LASTER, M. L.**
Advances at AEDC in treating transonic wind tunnel wall interference p 839 A86-49058
- LAVERS, B. F.**
Ageing aircraft as seen by an authority p 783 A86-47611

- LECCE, L.**
Control of interior noise in advanced turbopropeller aircraft p 802 A86-48100
- LECOMTE, P.**
The race for speed from the beginning of aviation to the present day p 761 A86-48980
- LEE, A. Y.**
Optimal landing of a helicopter in autorotation [AIAA PAPER 86-2287] p 793 A86-47705
- LEE, T. S.**
Optical detection methods for testing of fuel tank lightning ignition hazards p 791 A86-47309
- LEMBAYRE, A. H.**
Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection p 845 A86-47329
- LEHMAN, L. L.**
Fuel effects on aircraft combustor emissions [ASME PAPER 86-GT-212] p 815 A86-48252
- LEHMAN, L. L.**
RT-BUILD - Automatic generation of Ada code for flight control applications [AIAA PAPER 86-2088] p 852 A86-47439
- LEMMIN, J.**
An approach to an integrated control system for a modern fighter aircraft engine [ASME PAPER 86-GT-277] p 816 A86-48296
- LENZ, R. W.**
From mainframe to micro - Structures and flutter testing at the Air Force Flight Test Center p 838 A86-47791
- LESIEUTRE, D. J.**
Prediction of the aerodynamic characteristics of flight vehicles in large unsteady maneuvers p 834 A86-49048
- LEWIS, R. B., II**
Going where no man has gone before p 762 A86-49443
- LEWSEN, R.**
Evaluation of alternatives for an Army precision landing system [AD-A167780] p 789 N86-31554
- LEWY, S.**
Prediction of single-rotation prop-fan noise by a frequency domain scheme [ONERA, TP NO. 1986-100] p 818 A86-49125
- LIAPUNOV, S. V.**
Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809
- LIBRESCU, L.**
A general formulation for the aeroelastic divergence of composite sweptforward wing structures p 802 A86-49095
- LIEBST, B. S.**
Design of a multivariable flutter control/gust load alleviation system [AIAA PAPER 86-2247] p 825 A86-47494
- LIGHT, J. S.**
Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580
- LIGHTFOOT, W. E.**
Advanced concepts in small helicopter engine air-cooled turbine design p 819 A86-50075
- LIN, F.**
Some aspects of the reliability analysis of aircraft structures p 849 A86-49127
- LINSE, D. J.**
Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2 [NASA-CR-4014] p 836 N86-32440
- LIPIN, E. K.**
Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776
- LISSARAGUE, P.**
The race for speed from the beginning of aviation to the present day p 761 A86-48980
- LITTLE, W. L.**
Emergency underwater escape from helicopters p 784 A86-47745
- LIU, C.-H.**
Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258
- LIU, D. D.**
Oscillating wings and bodies with flexure in supersonic flow Applications of harmonic potential panel method p 776 A86-49108
- LIU, X.-S.**
Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
- LIU, Y.**
Aircraft maintenance in China - Approaches to modernization p 760 A86-47615

- LIUBIMOV, A. N.**
Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807
- LOC, T. P.**
A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers p 847 A86-48847
- LOEVE, W.**
An infrastructure for information processing for computer aided design [NLR-MP-85038-U] p 854 N86-33054
- LOMBARDI, G.**
Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044
- LONG, D. W.**
Evolution of the seawater activated release system (SEAWARS) p 784 A86-47756
- LOOZE, D. P.**
Simulation results of automatic restructurable flight control system concepts [AIAA PAPER 86-2032] p 821 A86-47422
- LORGE, F.**
Loran C 1984 spring-summer stability [AD-A167867] p 789 N86-31555
- LUCCHESINI, M.**
Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044
- LUNEV, A. A.**
The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation p 816 A86-48757
- LUTTGES, M.**
Comparisons in three-dimensionality in the unsteady flows elicited by straight and swept wings [AIAA PAPER 86-2280] p 764 A86-47698
- LUTTGES, M. W.**
Visualization of dynamic stall controlled by large amplitude interrupted pitching motions [AIAA PAPER 86-2281] p 764 A86-47699
- LUTTGES, M. W.**
Control of wake structure behind an oscillating airfoil [AIAA PAPER 86-2282] p 764 A86-47700
- M**
- MACCREADY, P.**
Long endurance aircraft performance p 805 A86-49478
- MACKENZIE, W. R.**
Low mass diffusion bonding tools [AD-D012295] p 851 N86-32746
- MADEN, K. H.**
The performance of a reverse flow combustor using JP 10 fuel [ASME PAPER 86-GT-146] p 814 A86-48202
- MADHURANATH, P.**
Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042
- MADSON, M. D.**
Application of the TranAir full-potential code to complete configurations p 772 A86-49009
- MAGLIERI, D. J.**
The impact of emerging technologies on an advanced supersonic transport p 761 A86-48997
- MAINE, R. E.**
Application of parameter estimation to highly unstable aircraft [AIAA PAPER 86-2020] p 827 A86-47655
- MAJUMDAR, A. K.**
Laser communication through low-visibility atmosphere for aircraft application p 788 A86-48581
- MAKAROV, L. N.**
The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833
- MALCOLM, G. N.**
Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack [AIAA PAPER 86-2277] p 830 A86-47695
- MALMUTH, N.**
Transonic wave drag estimation and optimization using the nonlinear area rule [AIAA PAPER 86-1798] p 778 A86-49582
- MALNEV, V. N.**
The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833
- MALTBY, M. R.**
Acceleration performance of helicopter engines [ASME PAPER 86-GT-121] p 814 A86-48180

- MANCHU, G.**
A method for transonic inverse cascade design with a stream function equation
[ASME PAPER 86-GT-189] p 766 A86-48239
- MANE, L.**
A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers
p 847 A86-48647
- MANFRIANI, L.**
Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements
p 774 A86-49044
- MANGANAS, A.**
Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control
[AIAA PAPER 86-2017] p 826 A86-47652
- MANIE, F.**
Leading edge vortex flow over a 75 degree-swept delta wing: Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
- MANNERS, B. A.**
Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing
p 845 A86-47613
- MARCEAU, J. A.**
Environmental durability testing
p 845 A86-47719
- MARCHMAN, J. F., III**
Analysis of the vortical flow around a 60 degree delta wing with vortex flap
p 774 A86-49050
- MARCOLINI, M. A.**
Airfoil trailing-edge flow measurements
p 780 A86-49803
- MAREK, C. J.**
Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels
[NASA-TM-87316] p 820 N86-31588
- MARESCA, C.**
Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592
- MARJANEK, P.**
Application of strain gauge methods to determination of in-flight loads of structure groups of small transport aircraft
p 811 A86-49149
- MARTELLI, F.**
Development of an experimental correlation for transonic turbine flow
[ASME PAPER 86-GT-108] p 765 A86-48170
- MARTENEY, P. J.**
Thermal decomposition of aircraft fuel
[ASME PAPER 86-GT-36] p 842 A86-48123
- MARTIN, C. A.**
Stability and control of aircraft with manual all-moving tailplanes
[AIAA PAPER 86-2231] p 829 A86-47692
- MARTIN, J. L.**
Flight evaluation of a precision landing task for a powered-lift STOL aircraft
[AIAA PAPER 86-2130] p 828 A86-47676
- MARTIN, N. A.**
Scott emergency escape breathing device - Evaluation for use in Canadian forces aircraft
p 784 A86-47731
- MARULO, F.**
Control of interior noise in advanced turbopropeller aircraft
p 802 A86-49100
- MASKEW, B.**
Unsteady low-speed aerodynamic model for complete aircraft configurations
[AIAA PAPER 86-2180] p 829 A86-47683
- MASKOW, J.**
Airbus-assembly concepts to improve productivity and flexibility in aircraft construction
p 761 A86-48999
- MATECKI, R.**
New technology propulsion (ANT) for general aviation aircraft, phase 1
[BMFT-FB-W-85-031] p 820 N86-31589
- MATROSOV, A. N.**
A study of the characteristics of separated flow past wings and lifting systems
p 770 A86-48842
- MATSUO, T.**
Identification of pilot dynamics in a system with a choice of feedback structures
[AIAA PAPER 86-2250] p 825 A86-47496
- MAX, H.**
Results of technology programs for general aviation aircraft at Dornier
p 795 A86-47787
- MAYO, M. H.**
Estimation of aerodynamic parameters from flight data of a high incidence research model
p 834 A86-49057
- MCCOMB, H. G., JR.**
Structural dynamics research in a full-scale transport aircraft crash test
p 785 A86-49053
Topics in landing gear dynamics research at NASA Langley
p 803 A86-49120
- MCCONNELL, P. M.**
Impact of higher freeze point fuels on naval aircraft operations
[ASME PAPER 86-GT-262] p 843 A86-48285
Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573
- McKENNA, P. M.**
Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system
p 790 A86-47305
- MCKNIGHT, R. C.**
In-flight photogrammetric measurement of wing ice accretions
[NASA-TM-87191] p 806 N86-31562
- McLARTY, J. L.**
Optimization of composite structures by controlled insertion or deletion of diverse fiber types
p 844 A86-50122
- McLAUGHLIN, A.**
Dynamic analysis: Correlation of theory with experiment
[RP661] p 851 N86-31917
- McQUADE, T. E.**
A preliminary investigation of H (infinity) optimization
[AIAA PAPER 86-2197] p 853 A86-47477
- MEECE, C. E.**
Subsonic/transonic stall flutter investigation of an advanced low pressure compressor
[ASME PAPER 86-GT-90] p 813 A86-48156
- MEHTA, R. S.**
Performance characteristics of an adaptive controller based on least-mean-square filters
[AIAA PAPER 86-2160] p 852 A86-47466
- MELVIN, W. W.**
Optimization and acceleration guidance of flight trajectories in a windshear
[AIAA PAPER 86-2036] p 822 A86-47425
Optimization and gamma/theta guidance of flight trajectories in a windshear
p 834 A86-49071
- MENDENHALL, M. R.**
Prediction of the aerodynamic characteristics of flight vehicles in large unsteady maneuvers
p 834 A86-49048
- MENON, P. K. A.**
A study of aircraft cruise
[AIAA PAPER 86-2286] p 792 A86-47704
- MENS, J.**
Computing codes for development of helicopter crashworthy structures and test substantiation
p 798 A86-48657
- MENSHIKOVA, V. L.**
Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics
p 768 A86-48783
The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps
p 771 A86-48849
- MENSIK, A.**
Practical applications of Tesla semiconductor pressure sensors
p 849 A86-49148
- MERHAV, S.**
Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms
[AIAA PAPER 86-2248] p 825 A86-47495
- MERHAV, S. J.**
Performance characteristics of an adaptive controller based on least-mean-square filters
[AIAA PAPER 86-2160] p 852 A86-47466
- MERRITT, F. J.**
ATRANS: An unsteady transonic code for clean wings
[NASA-TM-86783] p 781 N86-31535
- MIAO, W.-L.**
Rotor aeroelastic stability
p 798 A86-48664
- MICHAELSON, G. L.**
Case studies in aircraft manufacturing automation
p 762 A86-49000
- MICHELBERGER, P.**
Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load
p 849 A86-49128
- MIELE, A.**
Optimization and acceleration guidance of flight trajectories in a windshear
[AIAA PAPER 86-2036] p 822 A86-47425
Optimization and gamma/theta guidance of flight trajectories in a windshear
p 834 A86-49071
- MIGNOLI, A.**
Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions
[AAAF PAPER NT 85-06] p 838 A86-48457
- MIKHEEV, R. A.**
Oscillation equations for a helicopter rotor blade
p 800 A86-48805
- MIKUS, E.**
Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure
p 785 A86-48989
- MILEY, S. J.**
Wing laminar boundary layer in the presence of a propeller slipstream
p 776 A86-49122
- MILLARD, E. C.**
Adhesive selection from the user's viewpoint
p 841 A86-47715
Elevated-temperature-resistant adhesives
p 842 A86-47717
- MILLER, S. C.**
Future trends in propulsion
p 816 A86-48979
- MILLS, J. E.**
Working with today's BITE - One airline's experience
p 759 A86-47608
- MINAILOS, A. N.**
Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities
p 767 A86-48769
The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle
p 770 A86-48843
- MINAKUCHI, H.**
Configuration and trajectory of hypersonic transport with aerothermodynamic control
p 804 A86-49124
- MIODUSHEVSKII, P. V.**
Determination of the required number of channels for controlling aircraft wing loading for several cases of calculation
p 768 A86-48787
- MITCHELL, B.**
Evaluation of alternatives for an Army precision landing system
[AD-A167780] p 789 N86-31554
- MIYAZAKI, T.**
A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method
[ASME PAPER 86-GT-111] p 765 A86-48173
- MOGHADAM, A. H. KH.**
Wake/boundary-layer interactions in two and three dimensions
p 773 A86-49032
- MOKADAM, D. R.**
Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan
[ASME PAPER 86-GT-98] p 813 A86-48163
- MOKRY, M. J.**
Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method
p 839 A86-49060
- MOM, A. J. A.**
TURBISTAN: A standard load sequence for aircraft engine disks
[NLR-MP-85033-U] p 820 N86-32436
Cost reductions from introduction of new life philosophies for aircraft engine discs
[NLR-MP-85076-U] p 820 N86-32438
- MOORE, R. L.**
Aerodynamic delay following control actuation in a glider
[AIAA PAPER 86-2226] p 829 A86-47689
- MOREAU, J. P.**
Aircraft lightning attachment at low altitudes
p 791 A86-47317
- MORELLO, S. A.**
Flight management concepts compatible with air traffic control
p 788 A86-49018
- MORETTI, B.**
Practical implementation of a maintenance and engineering system in an airline
p 760 A86-47610
- MORGAN, D. H. S.**
Harrier the viffer
p 763 A86-49681
- MORGAN, H. L., JR.**
A new, improved method for separating turbulent boundary layer for aerodynamic performance prediction of trailing edge stall airfoils
[AIAA PAPER 86-1832] p 779 A86-49590
- MORRELL, F. R.**
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors
[AIAA PAPER 86-2030] p 810 A86-47511
- MORRIS, J.**
A propfan status report
p 817 A86-49091
- MOSES, C. A.**
Thermal stability concerns of Navy aviation fuel
[ASME PAPER 86-GT-94] p 842 A86-48159
- MOSKOVITZ, C.**
Forebody vortex management for yaw control at high angles of attack
p 833 A86-49047

- MOTYKA, P.**
Aircraft control surface failure detection and isolation using the OSGLR test
[AIAA PAPER 86-2028] p 821 A86-47419
- MOUL, M. T.**
Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model
p 796 A86-47800
- MOUNT, R. E.**
Stratified charge rotary engine for general aviation
[ASME PAPER 86-GT-181] p 815 A86-48231
- MOUSTAPHA, S. H.**
Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage
[ASME PAPER 86-GT-56] p 765 A86-48134
The effect of a downstream rotor on the measured performance of a transonic turbine nozzle
[ASME PAPER 86-GT-103] p 814 A86-48186
- MUELLER, A.**
Test and flight evaluation of precision distance measuring equipment
p 788 A86-49017
- MUELLER, E.**
Planning for minimum overhaul time
p 760 A86-47618
- MURAKAMI, A.**
Configuration and trajectory of hypersonic transport with aerothermodynamic control
p 804 A86-49124
- MURRAY, J. E.**
Application of parameter estimation to highly unstable aircraft
[AIAA PAPER 86-2020] p 827 A86-47655
- MURRI, D. G.**
Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control
p 833 A86-49039
Forebody vortex management for yaw control at high angles of attack
p 833 A86-49047
- MUSAFIR, R. E.**
Use of acoustic intensity measurements in the characterization of jet noise sources
p 855 A86-48740

N

- NACHTSHEIM, P. R.**
A knowledge-based expert system for scheduling of airborne astronomical observations
p 854 A86-49627
- NAIDU, D. S.**
Time scale analysis of a closed-loop discrete optimal control system
[AIAA PAPER 86-1995] p 852 A86-47417
- NAIK, D.**
An experimental study of a three lifting surface configuration
p 775 A86-49104
- NAKAHARA, S.**
Coatings
p 845 A86-47721
- NANEVICZ, J. E.**
Corona threshold determination by three-stage physical modelling of aircraft
p 792 A86-47333
- NASONKIN, I. M.**
The effect of a fault on the stiffness and the natural frequency of a plate in bending
p 850 A86-49918
- NASTASE, A.**
Optimum-Optimorum integrated wing-fuselage configuration for supersonic transport aircraft of second generation
p 801 A86-49010
- NAVAB, M.**
RT-BUILD - Automatic generation of Ada code for flight control applications
[AIAA PAPER 86-2088] p 852 A86-47439
- NAVERT, U. G.**
Transonic computations about complex configurations using coupled inner and outer flow equations
p 771 A86-49008
- NEJEDLY, V.**
Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve
p 804 A86-49138
- NEKRASOVA, M. N.**
Transonic flow past the root section of a wing with sweepback and sweepforward
p 769 A86-48817
- NELSON, D. J.**
Quantifying a propeller/engine power response rate mismatch
p 796 A86-47801
- NEUHOFF, F.**
Evaluation of the blade-to-blade flow from a high speed compressor rotor
[ASME PAPER 86-GT-117] p 765 A86-48176
- NEWSOM, J. R.**
Integrated structure/control design - Present methodology and future opportunities
p 854 A86-49094
- NGUYEN, L. T.**
Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control
p 833 A86-49039

- NIEDERSTADT, G.**
A round-up on CFRP
p 841 A86-47602
- NIEDZWIECKI, R. W.**
An overview of the Small Engine Component Technology (SECT) studies
[NASA-TM-88796] p 819 N86-31587
- NIKIFORUK, P. N.**
Synthesis of an adaptive flight controller under unknown deterministic disturbances
[AIAA PAPER 86-2157] p 823 A86-47464
- NIRANJANA, T.**
A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure
[NAL-TRM-SE-8603] p 782 N86-32393
- NIVEN, A. J.**
On the duration of low speed dynamic stall
p 773 A86-49033
- NIXON, D.**
Prediction of gust loadings and alleviation at transonic speeds
[AIAA PAPER 86-0997] p 777 A86-49573
- NOBACK, R.**
The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques
[NLR-TR-85014-U] p 809 N86-32430
- NOLL, T. E.**
Modelling of rigid-body and elastic aircraft dynamics for flight control development
[AIAA PAPER 86-2232] p 829 A86-47693
- NOMURA, S.**
Configuration and trajectory of hypersonic transport with aerothermodynamic control
p 804 A86-49124
- NORGREN, C. T.**
Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation
[AIAA PAPER 86-1452] p 818 A86-49611
Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation
[NASA-TM-87304] p 819 N86-31582
- NORMAN, T. R.**
Rotor tip vortex geometry measurements using the wide-field shadowgraph technique
[AIAA PAPER 86-1780] p 778 A86-49580
- NORTON, W. J.**
A proposed plane for the initial flight testing of a Rutan Aircraft Factory long-EZ and other light amateur experimental aircraft
p 794 A86-47777
- NUSCA, M. J.**
Parametric study of low Reynolds number precessing/spinning incompressible flows
[AIAA PAPER 86-2027] p 827 A86-47661

O

- OBAYASHI, S.**
Navier-Stokes simulation of transonic flow over wing-fuselage combinations
[AIAA PAPER 86-1831] p 779 A86-49589
- OBERRFRANZ, R.**
Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials
p 762 A86-49067
- OCH, G. M.**
Obstacle warning radar for helicopters - An anthropotechnical problem
p 787 A86-47769
- OGG, J. S.**
Durability and damage tolerance assessment of the TF34-100 engine
[ASME PAPER 86-GT-38] p 812 A86-48125
- OHMORI, Y.**
Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model
p 776 A86-49245
- OHNISHI, H.**
Optimum design technique for rotating wheels
[ASME PAPER 86-GT-255] p 846 A86-48281
- OKAPUU, U.**
Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage
[ASME PAPER 86-GT-56] p 765 A86-48134
- OLSEN, W. A., JR.**
Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels
[NASA-TM-87316] p 820 N86-31588
- OLSSON, J.**
Method of analysing data on a swept wing aircraft in flight
p 775 A86-49103
- ONDA, M.**
Lighter-than-air aircraft as control configured vehicle
p 801 A86-48998

- ONUMA, H.**
Calculations of high speed propeller performances using finite difference methods
p 818 A86-49126
- ORMISTON, R. A.**
Rotor-fuselage dynamic coupling characteristics of helicopter air and ground resonance
p 799 A86-48666
- OSHER, S. J.**
An entropy correction method for unsteady full potential flows with strong shocks
[AIAA PAPER 86-1768] p 777 A86-49576
- OSTOWARI, C.**
An experimental study of a three lifting surface configuration
p 775 A86-49104
- OSTROFF, A.**
Simulation results of automatic restructurable flight control system concepts
[AIAA PAPER 86-2032] p 821 A86-47422
- OSTROFF, A. J.**
Evaluation of total energy-rate feedback for glidescope tracking in wind shear
[AIAA PAPER 86-2035] p 822 A86-47424

P

- PADOVAN, J.**
Nonlinear dynamics of rotor/blade/casing rub interactions
[ASME PAPER 86-DE-6] p 818 A86-49620
- PADUANO, J. D.**
Sensitivity analysis of high-order digital flight control systems using singular-value concepts
[AIAA PAPER 86-2084] p 822 A86-47437
- PAGAN, D.**
Leading edge vortex flow over a 75 degree-swept delta wing Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
- PAHLE, J. W.**
Model-following control for an oblique-wing aircraft
[AIAA PAPER 86-2244] p 824 A86-47492
- PALKO, R. L.**
In-flight photogrammetric measurement of wing ice accretions
[NASA-TM-87191] p 806 N86-31582
- PAN, Y.**
Aircraft maintenance in China - Approaches to modernization
p 760 A86-47615
- PAONESSA, A.**
Control of interior noise in advanced turbopropeller aircraft
p 802 A86-49100
- PARAMASIVAM, T.**
Weight estimation techniques for composite airplanes in general aviation industry
* [NASA-CR-178163] p 781 N86-31531
- PARENTE, A. M.**
Stratified charge rotary engine for general aviation
[ASME PAPER 86-GT-181] p 815 A86-48231
- PARIS, S. W.**
Direct trajectory optimization using nonlinear programming and collocation
[AIAA PAPER 86-2000] p 841 A86-47902
- PARKER, L. W.**
Ranging and azimuthal problems of an airborne crossed loop used as a single-station lightning locator
p 809 A86-47325
- PARKINSON, G. V.**
Potential flow models of airfoils with separated flow
p 772 A86-49013
- PARKS, E. K.**
Angle-of-attack estimation for analysis of CAT encounters
p 831 A86-47798
- PARLINI, F.**
Precise control surface position measurements for hysteresis and twist testing
p 795 A86-47789
- PARYSHEVA, G. V.**
Determination of the statistical characteristics of aircraft motion during an automatic approach
p 832 A86-48844
- PATRI, G.**
Design bureaus: The brain drainers. I - Toulouse - Aircraft mobilize a task force over 1700-strong
p 763 A86-49464
- PATTON, R. J.**
A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy
[AIAA PAPER 86-2029] p 809 A86-47420
- PAULK, C. H., JR.**
Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779] p 789 N86-31551
- PAYNE, B. W.**
Designing a load alleviation system for a modern civil aircraft
p 832 A86-49006

- PAYNTER, G. C.**
CFD for engine-airframe integration
[ASME PAPER 86-GT-125] p 797 A86-48184
- PECK, W. R.**
Mach number immune microprocessor controlled sequencer for open ejection seats using on-board environmental sensors p 793 A86-47743
- PEIN, R.**
Regression rate study for a solid fuel ramjet p 818 A86-49113
- PELLOUX-GERVAIS, P.**
Development of a new lightweight emergency escape breathing device p 784 A86-47760
- PEMBERTON, W. G.**
Experts system control of autonomous airborne vehicle p 835 A86-49476
- PENNACCHIONI, B.**
New methods for in-flight vibration testing p 820 A86-47369
- PERALA, R. A.**
Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305
F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259
- PERKINS, S. C., JR.**
Prediction of the aerodynamic characteristics of flight vehicles in large unsteady maneuvers p 834 A86-49048
- PERRENOD, D. A.**
Aircrew protection design, training and mission management for high altitude aerodynamic operations p 761 A86-47778
- PERSON, L. H., JR.**
NASA B737 flight test results of the Total Energy Control System [AIAA PAPER 86-2143] p 826 A86-47516
- PETERS, H. J.**
Investigations in landing process of aircraft by means of the Monte-Carlo method [ESA-TT-951] p 808 N86-31578
- PETERS, J. M.**
Development of a controllable catapult for ejection seats p 793 A86-47733
- PETRY, J.**
Servo-actuator for sampled-data feedback disturbance rejection [DFVLR-FB-86-08] p 837 N86-32446
- PETTERSSON, B.**
Numerical design parameter study for slotted walls in transonic wind tunnels p 839 A86-49059
- PHILIPPE, J. J.**
Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows [ONERA, TP NO. 1986-101] p 776 A86-49106
- PHILPOTT, D. R.**
Intersection of an oblique shock wave with a cylindrical afterbody p 775 A86-49098
- PIAZZOLI, G.**
New methods for in-flight vibration testing p 820 A86-47369
Dynamic identification procedure and lift certification of light aircraft and gliders [ONERA-RT-12/1677-RY-090-R] p 809 N86-32429
- PINE, R.**
MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation [AIAA PAPER 86-2085] p 853 A86-47505
- PIROGOV, V. V.**
The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833
- PITTS, F. L.**
F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259
- PLUMER, J. A.**
Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318
- POCHKINA, K. A.**
Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
- POLITO, L.**
Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044
- POLYCHRONIADIS, M.**
Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter [SNIAS-861-210-108] p 836 N86-32444
- POLZ, G.**
Development of the BO 105 LS [MBB-UD-456-85-OE] p 805 A86-50255
- PONZI, C.**
Aeroelastic tailoring for flutter constraints p 802 A86-49081
- POOLE, R. J. D.**
Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method p 839 A86-49060
- POPE, D. S.**
Airfoil trailing-edge flow measurements p 780 A86-48803
- PORTER, B.**
Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control [AIAA PAPER 86-2017] p 826 A86-47652
- PORTNOY, H.**
Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049
- POSINGIES, W.**
Control reconfigurable combat aircraft flight control system development [AIAA PAPER 86-2236] p 824 A86-47488
- POWELL, C. W.**
Aspects of lightning protection schemes for radomes p 792 A86-47338
- PRICE, D. B.**
Time scale analysis of a closed-loop discrete optimal control system [AIAA PAPER 86-1995] p 852 A86-47417
- PRIEST, J. E.**
Turbulence response matching in the NT-33A in-flight simulator [AIAA PAPER 86-2076] p 827 A86-47665
- PROSKAWETZ, K.-O.**
Flight path reconstruction - A powerful tool for data compatibility check p 833 A86-49041
- PROZOROV, A. G.**
Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
- PURCELL, C. J.**
Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027

Q

- QIU, C.**
The dynamic response of a variable sweep aircraft in the course of changing geometry [AIAA PAPER 86-2234] p 829 A86-47694
- QUAST, A.**
Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983
- QUSEN, Z.**
Manufacturing technology of composite torque box of vertical fin p 848 A86-49068

R

- RADESPIEL, R.**
Efficient solution of three-dimensional Euler equations using embedded grids p 771 A86-49007
- RADOSAVLJEVIC, V. LJ.**
Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading p 848 A86-49040
- RADVOGIN, IU. B.**
Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 768 A86-48783
The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps p 771 A86-48849
- RAHLFS, D.**
Low cost inertial reference system based on fiber gyros with GPS-aiding p 788 A86-49016
- RAHN, D.**
Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563
- RAHULAN, T.**
Active flutter suppression p 832 A86-49004
- RAJ, P.**
Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043
- RAJAN, S. R.**
A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure [NAL-TRM-SE-8603] p 782 N86-32393
- RAMACHANDRA, S. M.**
An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow [AIAA PAPER 86-0467] p 856 A86-49586
- RAMAZANOV, M. P.**
Method for the visualization of subsonic gas flows p 769 A86-48808
- RAO, D. M.**
Forebody vortex management for yaw control at high angles of attack p 833 A86-49047
Low-speed aerodynamics of apex fences on a tailless delta configuration [AIAA PAPER 86-1838] p 779 A86-49593
- RAUH, G.**
Aircraft/engine integration for an advanced fighter considering mission specifics [ASME PAPER 86-GT-295] p 797 A86-48308
- REDEKER, G.**
Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983
- REED, E. J.**
Life cycle cost methodology for preliminary design evaluation [ASME PAPER 86-GT-37] p 812 A86-48124
- REEVES, C. M.**
Fuel effects on aircraft combustor emissions [ASME PAPER 86-GT-212] p 815 A86-48252
- REICHERT, G.**
Dynamic aspects in the design of advanced rotor systems p 798 A86-48663
- REICHOW, D.**
Potential of BITE's and what it means to aircraft maintenance p 759 A86-47607
- REINERTSON, L.**
Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563
- REINHOLD, R. R.**
Durability and damage tolerance assessment of the TF34-100 engine [ASME PAPER 86-GT-38] p 812 A86-48125
- RENZ, R. R. L.**
A minimum approach to flight testing p 810 A86-47780
- RHODES, F. E.**
Plastic or metal - The judgement factors p 762 A86-49037
- RICKET, J. L.**
Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip [NASA-TM-87722] p 781 N86-31532
- RIQUEL, G.**
High voltage laboratory tests and lightning phenomena p 844 A86-47312
- RIST, D.**
Comparison of methods for lifetime calculations of highly loaded aero-engine discs [ASME PAPER 86-GT-102] p 814 A86-48165
- RITTER, A.**
Advances at AEDC in treating transonic wind tunnel wall interference p 839 A86-49058
- RITTER, J.**
Weight estimation techniques for composite airplanes in general aviation industry [NASA-CR-178163] p 781 N86-31531
- RIU, J.-P.**
High voltage laboratory tests and lightning phenomena p 844 A86-47312
- RIZZI, A.**
Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027
- ROBB, J. D.**
Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305
Optical detection methods for testing of fuel tank lightning ignition hazards p 791 A86-47309
Ring discharge on the backsurface of a composite skin with ohmic anisotropy in response to frontal high current injection p 845 A86-47329
- ROBBINS, R. D.**
Aerial refueling evaluation of the CH-47D helicopter [AD-A167575] p 808 N86-31574
- ROBINSON, M. C.**
Visualization of dynamic stall controlled by large amplitude interrupted pitching motions [AIAA PAPER 86-2281] p 764 A86-47699
Control of wake structure behind an oscillating airfoil [AIAA PAPER 86-2282] p 764 A86-47700
- RODGERS, C.**
A jet fuel starter and expendable turbojet [ASME PAPER 86-GT-1] p 812 A86-48101

- ROHLF, D.**
Identification of gust input and gust response characteristics from Do 28 TNT flight test data [ESA-TT-919] p 837 A86-32445
- ROMEO, G.**
Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003
- RONEN, T.**
Dynamics of a helicopter with a sling load [AIAA PAPER 86-2288] p 831 A86-47709
- ROSE, J.**
Maintainability optimization - The future challenge p 762 A86-49052
- ROSS, A.**
Analysis of a mirror deck landing aid [AD-A167988] p 789 A86-31556
- ROSS, C. F.**
Active noise control p 803 A86-49101
- ROY, R. H.**
Real-time flutter identification with close mode resolution [AIAA PAPER 86-2019] p 827 A86-47654
- RUDOLPH, T. H.**
Implementation of a crowbar switch in a Marx generator/peaking capacitor lightning simulator system p 790 A86-47305
F-106 data summary and model results relative to threat criteria and protection design analysis p 786 A86-50259
- RUSTAN, P. L., JR.**
Aircraft lightning attachment at low altitudes p 791 A86-47317
- RYAN, H. M.**
Aspects of lightning protection schemes for radomes p 792 A86-47338
- RYBAKOV, F. V.**
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48846
- RYNASKI, E. G.**
The interpretation of flying qualities requirements for flight control design [AIAA PAPER 86-2249] p 826 A86-47523
- S**
- SACHS, G.**
Reducing fuel consumption by cyclic control p 832 A86-48991
- SAMUELSON, A.**
Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055
- SANTINI, P.**
ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volumes 1 & 2 p 761 A86-48976
- SANZ, A.**
Cancellation zone in supersonic lifting wing theory p 780 A86-49824
- SARRAFIAN, S. K.**
Effect of time delay on flying qualities - An update [AIAA PAPER 86-2202] p 823 A86-47482
Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672
- SASAKI, M.**
A study on NOx emissions from gas turbine combustor [ASME PAPER 86-GT-168] p 814 A86-48220
- SATTLER, D. E.**
Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator [AIAA PAPER 86-2205] p 787 A86-47519
- SAUER, G.**
On the computation of wing lift interference caused by high bypass engines p 776 A86-49109
- SAUNDERS, C. P. R.**
Field observations of aircraft charging in convective clouds p 783 A86-47332
- SAYER, R. B.**
Residual strength prediction for planked wing tension surfaces [AIAA PAPER 86-0941] p 849 A86-49572
- SCHABOWSKY, R. S., JR.**
A methodology for evaluating the operational performance of an aircraft in a tactical environment [AIAA PAPER 86-2095] p 759 A86-47444
- SCHAEFER, C. G., JR.**
Acoustic effect on stall hysteresis for low Reynolds number laminar flow p 855 A86-47971
- SCHAEZNER, G.**
Design criteria for flight control systems p 833 A86-49023

- SCHIPPERS, H.**
Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches [AIAA PAPER 86-1821] p 778 A86-49586
- SCHMIDT, D. K.**
Cooperative synthesis of control and display augmentation [AIAA PAPER 86-2204] p 853 A86-47484
On the flight dynamics of aeroelastic vehicles [AIAA PAPER 86-2077] p 828 A86-47666
A fundamental approach to equivalent systems analysis [AIAA PAPER 86-2128] p 828 A86-47674
Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 A86-31590
- SCHMITENDORF, W. E.**
A design methodology for robust stabilizing controllers [AIAA PAPER 86-2195] p 823 A86-47475
A controller for robust asymptotic tracking in systems with time-varying uncertainties [AIAA PAPER 86-2199] p 853 A86-47479
- SCHNEIDER, H.**
Live tests on static electricity in fuelling of aircraft p 783 A86-47334
- SCHNEIDER, J. G.**
Design of a fast risetime lightning generator p 837 A86-47304
- SCHOBEIRI, T.**
A general computational method for simulation and prediction of transient behavior of gas turbines [ASME PAPER 86-GT-180] p 815 A86-48230
- SCHOEBERL, H. W.**
Can future aircraft maintenance be afforded? p 857 A86-47617
- SCHOENMAN, R. L.**
Thirty years with the jets: Commercial transport flight management systems - Past, present, and future [AIAA PAPER 86-2289] p 821 A86-47402
- SCHOFIELD, J. M.**
The competitive and cooperative outlook for aircraft propulsion systems [AIAA PAPER 86-1134] p 857 A86-49571
- SCHULTE, G.**
Regression rate study for a solid fuel ramjet p 818 A86-49113
- SCHULTZ, E. R.**
Robotic systems concepts for the rapid turnaround of tactical aircraft in a biochemical environment p 761 A86-47763
- SCHULTZ, K.-J.**
Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061
- SCHUTTE, P. C.**
An artificial intelligence approach to onboard fault monitoring and diagnosis for aircraft applications [AIAA PAPER 86-2093] p 853 A86-48577
- SCHWEIGER, J.**
Aeroelastic tailoring for flutter constraints p 802 A86-49081
- SCHWEIKHARD, W. G.**
A minimum approach to flight testing p 810 A86-47780
- SEDIN, Y. C.-J.**
Transonic computations about complex configurations using coupled inner and outer flow equations p 771 A86-49008
Numerical design parameter study for slotted walls in transonic wind tunnels p 839 A86-49059
- SEECK, D.**
Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783
- SEGINER, A.**
Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046
- SELLERS, W. L., III**
Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg [AIAA PAPER 86-1775] p 777 A86-49579
- SEND, W.**
The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102
- SENN, C. P.**
Flight testing in the aircraft carrier environment p 794 A86-47779
- SENSBURG, O.**
Aeroelastic tailoring for flutter constraints p 802 A86-49081
- SERAUDIE, A.**
Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions [AAAF PAPER NT 85-06] p 838 A86-48457

- SEREBRIISKII, I. A. M.**
Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809
- SEREGIN, V. P.**
The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963
- SETO, L. Y.**
On the duration of low speed dynamic stall p 773 A86-49033
- SHAH, S. C.**
RT-BUILD - Automatic generation of Ada code for flight control applications [AIAA PAPER 86-2088] p 852 A86-47439
- SHAMIE, J.**
Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis p 799 A86-48667
- SHANKAR, V.**
Validation of a full potential method for combined yaw and angle of attack [AIAA PAPER 86-1834] p 779 A86-49591
- SHARMA, O. P.**
Predictions of endwall losses and secondary flows in axial flow turbine cascades [ASME PAPER 86-GT-228] p 766 A86-48262
- SHAW, R. J.**
NASA's aircraft icing analysis program p 786 A86-49107
NASA's Aircraft Icing Analysis Program [NASA-TM-88791] p 786 A86-31548
- SHAYESON, M. W.**
Thermal stability concerns of Navy aviation fuel [ASME PAPER 86-GT-94] p 842 A86-48159
- SHELTON, R. W.**
The energy requirements of an aircraft triggered discharge p 844 A86-47315
- SHEN, G. C.**
Intersection of an oblique shock wave with a cylindrical afterbody p 775 A86-49098
- SHIMONAEV, G. S.**
An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography p 844 A86-49964
- SHINAR, J.**
Concept of automated aircraft guidance system for air-to-air missions [AIAA PAPER 86-2285] p 787 A86-47703
Near-optimal feedback control for three-dimensional interceptions p 854 A86-48992
- SHIOTA, Y.**
Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
- SHIRK, M. H.**
The development of aeroelastic tailoring in the United States p 805 A86-50111
- SHREEVE, R. P.**
Evaluation of the blade-to-blade flow from a high speed compressor rotor [ASME PAPER 86-GT-117] p 765 A86-48176
- SHURYGIN, V. M.**
Determination of off-design flowrates according to the position of branching points on an under-the-wing (over-the-wing) air intake p 769 A86-48812
- SIDOROV, O. T.**
The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918
- SIGMAN, R. K.**
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806
- SIKORA, J. S.**
Free-vortex flow simulation using a three-dimensional Euler aerodynamic method p 773 A86-49043
- SILVERTHORN, J. T.**
Flight test evaluation of techniques to predict longitudinal pilot induced oscillations [AIAA PAPER 86-2253] p 826 A86-47509
- SIMOVICH, J.**
A general formulation for the aeroelastic divergence of composite sweptforward wing structures p 802 A86-49095
- SINGER, H.**
Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295
- SINHA, N.**
Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- SINN, W.**
Handling qualities and flight performance - Implication of the operational envelope p 799 A86-48672
- SKOMOROKHOV, S. I.**
Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767

SKOVORODIN, G. B.

The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963

SKOW, A. M.

Enhanced controllability through vortex manipulation on fighter aircraft at high angles of attack
[AIAA PAPER 86-2277] p 830 A86-47695

F-5E departure warning system algorithm development and validation
[AIAA PAPER 86-2284] p 830 A86-47702

SLAMA, J. G.

Use of acoustic intensity measurements in the characterization of jet noise sources p 855 A86-48740

SMETANA, J.

Strain-gauge autopilot altitude corrector p 811 A86-49142

SMITH, G. E.

Application of a full potential method to practical problems in supersonic aircraft design and analysis p 773 A86-49030

SMITH, R. E.

Effect of time delay on flying qualities - An update
[AIAA PAPER 86-2202] p 823 A86-47482
Algebraic grid generation about wing-fuselage bodies p 772 A86-49028

SMITH, S. C.

Stability and control of aircraft with manual all-moving tailplanes
[AIAA PAPER 86-2231] p 829 A86-47692

SMOLIANINOVA, T. D.

Oscillation equations for a helicopter rotor blade p 800 A86-48805

SNYDER, C. A.

A parametric study of a gas-generator air turbo ramjet (ATR)
[NASA-TM-88808] p 819 N86-31586

SOBANSKI, K. J.

Multiple thermocouple testing device
[AD-D012276] p 850 N86-31860

SOBIECZKY, H.

Aerodynamic design methods for modern transport aircraft
[ESA-TT-923] p 782 N86-31543

SOBOR, A.

Method for determining the ISO-noise levels by simulated aircraft flight operations p 856 A86-49099

SOIRON, M.

Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296

SOKOLOVA, G. I.

The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963

SOKOLOVA, I. N.

Similarity criteria for a circulation control airfoil p 769 A86-48815

SOKOLOWSKI, D. E.

Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads
[ASME PAPER 86-GT-172] p 815 A86-48224

SOLIGNAC, J. L.

Leading edge vortex flow over a 75 degree-swept delta wing Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042

SORENSEN, J. A.

Design factors and considerations for a time-based flight management system
[AIAA PAPER 86-2144] p 822 A86-47455

SORENSEN, R. L.

Elliptic generation of composite three-dimensional grids about realistic aircraft
[NASA-TM-88240] p 763 N86-31527

SORNAS, L.

Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055

SOROKIN, I. U. S.

Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807

SOULAGE, R. G.

Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299

SOURIAL, N.

Power turbine vane ring (PT6 engine) repair development
[ASME PAPER 86-GT-2] p 812 A86-48102

SPADACCINI, L. J.

Thermal decomposition of aircraft fuel
[ASME PAPER 86-GT-36] p 842 A86-48123

SPECKER, L. J.

Flow stagnation as an advanced windblast protection technique p 793 A86-47727

SPERLING, E.

Shimmy problems of landing gears caused by elastic deformation of tires p 803 A86-49118

SPEYER, J. L.

An explicit adaptive flight control system based on the modified gain extended Kalman filter
[AIAA PAPER 86-2158] p 823 A86-47465

SPITZER, C. R.

Advanced ATC - An aircraft perspective p 788 A86-49637

SPLETTSTOESSER, W. R.

Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061

SQUIRE, L. C.

Wake/boundary-layer interactions in two and three dimensions p 773 A86-49032

SRIDHAR, J. K.

Six degree of freedom simulation software
[NAL-PD-SE-8614] p 854 N86-33042

SRINIVASAN, R.

Perspectives on dilution jet mixing
[AIAA PAPER 86-1611] p 818 A86-49614

SRIVATSAN, R.

Development of a takeoff performance monitoring system
[NASA-TM-89001] p 835 N86-31591

STANEWSKY, E.

Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer p 775 A86-49074

STATECNY, J.

A contribution to airworthiness certification of gas turbine disks p 849 A86-49136

STAUFENBIEL, R.

ICAS, Congress, 15th, London, England, September 7-12, 1986, Proceedings. Volumes 1 & 2 p 761 A86-48976

STEINHOFF, J.

Blending method for grid generation p 766 A86-48428

STENGEL, R. F.

A theory for fault-tolerant flight control combining expert system and analytical redundancy concepts
[AIAA PAPER 86-2092] p 822 A86-47442

Optimal control laws for microburst encounter p 834 A86-49070

STEVENS, V. C.

The ground effects of a powered-lift STOL aircraft during landing approach p 795 A86-47784

STEWART, J. D.

Operation of the CT7 turboprop engine as an auxiliary power unit (APU)
[ASME PAPER 86-GT-28] p 812 A86-48119

STEWART, J. F.

Development of HIDECA adaptive engine control systems
[ASME PAPER 86-GT-252] p 816 A86-48278

STIER, T.

Avionics fault data acquisition - A concept for civil transport aircraft p 810 A86-49051

STILES, W.

F-14A low-altitude asymmetric thrust simulation and flight test program p 795 A86-47785

STOHLGREN, L. M.

The GTPC36-300 - A gas turbine auxiliary power unit for advanced technology transport aircraft
[ASME PAPER 86-GT-285] p 816 A86-48302

STOLIAROV, G. I.

A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack p 767 A86-48762

STRACK, W. C.

Aeropropulsion opportunities for the 21st century
[NASA-TM-88817] p 819 N86-31585

STRAUB, F.

Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis p 799 A86-48667

STRYGIN, V. Z.

Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760

STURMER, S. R.

Pitch rate sensitivity criterion for category C flight phases - Class IV aircraft
[AIAA PAPER 86-2201] p 823 A86-47481

STUTZ, J. C.

A knowledge-based expert system for scheduling of airborne astronomical observations p 854 A86-49627

SUDAKOV, G. G.

Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779

SUDANI, N.

Configuration and trajectory of hypersonic transport with aerothermodynamic control p 804 A86-49124

SUGIURA, I.

Airplane landing behaviors controlled by man-pilots p 835 A86-49244

SUIKAT, R.

Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2
[NASA-CR-4014] p 836 N86-32440

SUKHANOV, V. L.

Self-oscillatory regimes of aircraft motion during spin-roll coupling p 832 A86-48775

SULLIVAN, P. J.

Aerial refueling evaluation of the CH-47D helicopter
[AD-A167575] p 808 N86-31574

SUN, X.

The dynamic response of a variable sweep aircraft in the course of changing geometry
[AIAA PAPER 86-2234] p 829 A86-47694

SUNG, B.

Analysis of the vortical flow around a 60 degree delta wing with vortex flap p 774 A86-49050

SWEETMAN, B.

Fighter power for the 1990s p 816 A86-48369

SWENSON, H. N.

Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations
[NASA-TM-86779] p 789 N86-31551

SWIERSTRA, S.

A simulation facility for assessing the next generation of 4-D air traffic control procedures p 788 A86-49034

SYLER, R. P.

Airborne intruder detection considerations
[DE86-006462] p 808 N86-31576

SZABO, Z.

Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load p 849 A86-49128

SZEMA, K.-Y.

Validation of a full potential method for combined yaw and angle of attack
[AIAA PAPER 86-1834] p 779 A86-49591

T**TABAKOFF, W.**

Particulate flow solutions through centrifugal impeller with two splitters
[ASME PAPER 86-GT-130] p 765 A86-48188

TANCK, C. L.

Influence of EFCS-control laws on structural design of modern transport aircraft p 800 A86-48984

TANEDA, M.

Optimum design technique for rotating wheels
[ASME PAPER 86-GT-255] p 846 A86-48281

TANNER, J. A.

Topics in landing gear dynamics research at NASA Langley p 803 A86-49120

TASK, H. L.

Portable glide slope indicator
[AD-D012240] p 789 N86-31552

TAVELLA, D. A.

Aerodynamics of delta wings with leading edge blowing
[AIAA PAPER 86-2230] p 764 A86-47691

TAYLOR, J. H.

F-5E departure warning system algorithm development and validation
[AIAA PAPER 86-2284] p 830 A86-47702

TELEKI, A.

BK 117 flight tests for certification of an expanded flight envelope
[MBB-UD-452-85-OE] p 805 A86-50253

TENHAVE, A. A.

TURBISTAN: A standard load sequence for aircraft engine disks
[NLR-MP-85033-U] p 820 N86-32436

TENLY, W. Y.

Pressure measurements in a liquid-filled cylinder using a three-degree-of-freedom flight simulator
[AIAA PAPER 86-2026] p 827 A86-47660

TEPERIN, L. L.

Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767

TER HASEBORG, J. L.

Special protection circuits against transient currents for aircraft systems p 791 A86-47326

THIBERT, J. J.

Evaluation and reduction of drag
[AAAF PAPER NT 85-01] p 766 A86-48452

THIELE, TH.

Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331

THOMAS, D.

Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782

THOMAS, J.

A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations [ESA-TT-928] p 789 N86-31558

THOMPSON, D.

Automated structural optimisation at Warton p 854 A86-48987

THOMPSON, R. L.

Unified constitutive materials model development and evaluation for high-temperature structural analysis applications p 849 A86-49133

THOMSON, R. G.

Structural dynamics research in a full-scale transport aircraft crash test p 785 A86-49053

THORNTON, B. S.

Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064

THRALL, E. W.

Environmental-durability testing p 845 A86-47719
Structural analysis of adhesive-bonded joints p 846 A86-47722

TIMERBULATOV, A. M.

An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen p 770 A86-48841

TIPPEY, D. K.

The INS wind calibration in climb algorithm p 796 A86-47799

TJONNELAND, E.

CFD for engine-airframe integration [ASME PAPER 86-GT-125] p 797 A86-48184

TO, P. T.

A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054

TONG, M. T.

Unified constitutive materials model development and evaluation for high-temperature structural analysis applications p 849 A86-49133

TOPP, D. A.

Splitter blades as an aeroelastic detuning mechanism for unstalled supersonic flutter of turbomachine rotors [ASME PAPER 86-GT-99] p 813 A86-48164

TRIEBSTEIN, H.

Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows [ONERA, TP NO. 1986-101] p 776 A86-49106

TRIKNA, A. K.

Sensor selection for the Boeing CREST ejection seat design p 793 A86-47757
Boeing control law for CREST demonstration ejection seat p 794 A86-47758

TRINKS, H.

Special protection circuits against transient currents for aircraft systems p 791 A86-47326

TSYBATOV, V. A.

Optimization of onboard systems of data acquisition and processing p 810 A86-48531

TSYGANOV, P. G.

The drag of a pair of bodies at supersonic flight velocities p 768 A86-48802

TSYMBALIUK, V. I.

Calculation of the loading of the airframe in flight due to multidimensional turbulence p 799 A86-48759

TUBBS, H.

Advances in turbine technology p 817 A86-49079

TUCK, D. A.

Civil helicopter handling qualities requirements for visual and instrument flight p 832 A86-48674

TURNER, D. M.

Case studies of the effects on non-linearities on the accuracy of gas turbine control p 817 A86-49090

TZUO, K. L.

Prediction of gust loadings and alleviation at transonic speeds [AIAA PAPER 86-0997] p 777 A86-49573

U

UCHIKADO, S.

Synthesis of an adaptive flight controller under unknown deterministic disturbances [AIAA PAPER 86-2157] p 823 A86-47464

URDA, T. J.

Design of a vertical thrust stand for a remotely piloted model helicopter [AD-A167811] p 840 N86-31598

URNES, J. M.

An all-weather multimode landing system for tactical fighter aircraft [AIAA PAPER 86-2146] p 787 A86-47517

USHAKOV, I. E.

Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776

V

VALAREZO, W. O.

Time-averaged subsonic propeller flowfield calculations [AIAA PAPER 86-1807] p 778 A86-49584

VAN DAM, C. P.

Boundary-layer transition effects on airplane stability and control [AIAA PAPER 86-2229] p 831 A86-47708

VAN DER GEEST, P. J.

Flight simulation of MLS interception procedures applicable to laterally segmented approach paths [AIAA PAPER 86-2073] p 837 A86-47663

VAN GELDER, P. A.

Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model [AIAA PAPER 86-2242] p 824 A86-47490

VANCE, E. F.

Corona threshold determination by three-stage physical modelling of aircraft p 792 A86-47333

VANCO, M. R.

An overview of the Small Engine Component Technology (SECT) studies [NASA-TM-88796] p 819 N86-31587

VANDENDAM, R. F.

Simulation and optimization techniques in computer aided design [NLR-MP-85022-U] p 854 N86-33053

VANDOORN, J. T. M.

Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program [NLR-MP-84023-U] p 811 N86-32431

VANKASTEEL, J.

Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system [NPL-VG-84-009-L] p 789 N86-32419

VASILIEV, G. V.

On the optimization of flutter characteristics of laminated anisotropic cylindrical shells p 848 A86-49082

VEAUX, J.

New design procedures applied to landing gear development p 803 A86-49117

VELGER, M.

Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495

VERHAEGEN, M. H.

A robust adaptive flightpath reconstruction technique [AIAA PAPER 86-2018] p 826 A86-47653

VERRIERE, J.

Identification of unsteady response in rudders at low velocities [AAAF PAPER NT 85-19] p 797 A86-48468

VETTER, J. E.

The risk of collision in a two seat aircraft ejection p 783 A86-47730

VICROY, D. D.

Design factors and considerations for a time-based flight management system [AIAA PAPER 86-2144] p 822 A86-47455

VITTIKH, V. A.

Optimization of onboard systems of data acquisition and processing p 810 A86-48531

VIZEL, E. P.

A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842

VIZZINI, R. W.

Engine control reliability and durability improvement through accelerated mission environmental testing [ASME PAPER 86-GT-52] p 813 A86-48132

VLADIMIROVA, N. A.

Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809

VNUKOV, A. E.

Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack p 770 A86-48825

VOEVODIN, A. V.

Determination of the aerodynamic characteristics of separated flow past a wing with allowance for slight unsteadiness induced by changes in angle of attack p 769 A86-48816

VOGEL, S.

Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows [ONERA, TP NO. 1986-101] p 776 A86-49106

VOITYSHEN, V. S.

Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845

VON GLAHN, U. H.

Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust [AIAA PAPER 86-1809] p 778 A86-49585

VON MEIER, U.

Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782

VON TEIN, V.

Modern developments in rotorcraft technology [MBB-UD-458-85-OE] p 805 A86-49509

VRHEL, J.

Experience with stress analysis during airframe fatigue tests p 840 A86-49143

VYSHINSKII, V. V.

The effect of the aspect ratio of the cylindrical section on the fuselage drag at transonic flight velocities p 768 A86-48801

Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809

W

WAGDI, M. N.

A stochastic decentralized flight control system [AIAA PAPER 86-1994] p 821 A86-47416

WAGNER, E.

Aircraft control surface failure detection and isolation using the OSGLR test [AIAA PAPER 86-2028] p 821 A86-47419

WAGNER, R. D.

Laminar flow research applicable to subsonic aircraft p 781 A86-50269

WAI, J. C.

PN/S calculations for a fighter W/F at high-lift yaw conditions [AIAA PAPER 86-1829] p 779 A86-49588

WALKER, R. A.

Robust fault detection and isolation for a high performance aircraft on STOL approach [AIAA PAPER 86-2031] p 821 A86-47421

Real-time flutter identification with close mode resolution [AIAA PAPER 86-2019] p 827 A86-47654

WALKLEY, K. B.

Application of a full potential method to practical problems in supersonic aircraft design and analysis p 773 A86-49030

WALKO, L. C.

Design of a fast risetime lightning generator p 837 A86-47304

Lightning simulation tests on FAA CV-580 lightning research aircraft p 790 A86-47307

WALSH, T. P.

A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP [AD-A167719] p 808 N86-31575

WANG, S.-C.

The helicopter technology of China p 761 A86-48652

A study of stability and control of a hingeless rotor helicopter with non-uniform induced velocity field p 831 A86-48655

WANG, T.

Optimization and acceleration guidance of flight trajectories in a windshear [AIAA PAPER 86-2036] p 822 A86-47425

Optimization and gamma/theta guidance of flight trajectories in a windshear p 834 A86-49071

WANG, W. P.

Research on active suppression technology for wing/aileron flutter p 835 A86-49096

WANG, Y.-Y.

Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model p 776 A86-49245

WANHILL, R. J. H.

Fatigue fracture in landing gear steels p 803 A86-49115

Short cracks in aerospace structures [NLR-MP-85054-U] p 851 N86-32781

WARD, D. T.

Use of hinged strakes for lateral control at high angles of attack [AIAA PAPER 86-2278] p 830 A86-47696

- WARREN, D. G.**
Area equivalent method (AEM) on VISICALC and LOTUS 1-2-3 - The Federal Aviation Administration's spreadsheet programs for predicting noise exposure contour areas around an airport p 853 A86-48595
- WASZAK, M. R.**
On the flight dynamics of aeroelastic vehicles [AIAA PAPER 86-2077] p 828 A86-47666
- WATKINS, T. JR.**
Evaluation of damage tolerance requirements using a probabilistic-based life approach [ASME PAPER 86-GT-266] p 847 A86-48288
- WATSON, D. M.**
Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676
- WEBB, L.**
Advanced icing wind tunnel for flight test development of icing rate systems p 838 A86-47792
- WEDDERSPOON, J. R.**
The high lift development of the A320 aircraft p 772 A86-49012
- WEICHELT, G. A.**
An all-weather multimode landing system for tactical fighter aircraft [AIAA PAPER 86-2146] p 787 A86-47517
- WEIHS, D.**
On the motion of spray drops in the wake of an agricultural aircraft p 777 A86-49441
- WEINGARTEN, N. C.**
The interpretation of flying qualities requirements for flight control design [AIAA PAPER 86-2249] p 826 A86-47523
- WEINGOLD, H. D.**
The use of surface static pressure data as a diagnostic tool in multistage compressor development [ASME PAPER 86-GT-3] p 812 A86-48103
- WEINSTEIN, W.**
Control reconfigurable combat aircraft flight control system development [AIAA PAPER 86-2236] p 824 A86-47488
- WEISENSEE, U.**
Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results p 767 A86-48568
- WEISS, J. L.**
Simulation results of automatic restructurable flight control system concepts [AIAA PAPER 86-2032] p 821 A86-47422
- WEISSHAAR, T. A.**
Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- The development of aeroelastic tailoring in the United States p 805 A86-50111
- WELL, K. H.**
Near-optimal feedback control for three-dimensional interceptions p 854 A86-48992
- WELLS, I. M.**
An improved optical viewing system for a flight simulator [MS-8025] p 840 N86-32448
- WELTE, D.**
New technology propulsion (ANT) for general aviation aircraft, phase I [BMFT-FB-W-85-031] p 820 N86-31589
- WEN, Q.-C.**
Use and maintenance of helicopters on the plateau p 785 A86-48669
- WERNER, L. D.**
The GTPC36-300 - A gas turbine auxiliary power unit for advanced technology transport aircraft [ASME PAPER 86-GT-285] p 816 A86-48302
- WESTON, R. P.**
Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg [AIAA PAPER 86-1775] p 777 A86-49579
- WHIPPLE, R. D.**
Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip [NASA-TM-87722] p 781 N86-31532
- WHITE, E. G.**
Development of a new lightweight emergency escape breathing device p 784 A86-47760
- WHITE, E. R.**
Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model p 796 A86-47800
- WHITE, J. F., III**
Aeroelastic behavior of low aspect ratio metal and composite blades [ASME PAPER 86-GT-243] p 846 A86-48271
- WHITESIDE, P. V.**
The British Aerospace Experimental Aircraft Programme and the role of system development cockpits p 801 A86-48996
- WHITLEY, P. E.**
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738
- WHITFLOW, W., JR.**
An entropy correction method for unsteady full potential flows with strong shocks [AIAA PAPER 86-1768] p 777 A86-49576
- WICHMANN, G.**
Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB) [ESA-TT-916-PT-2] p 782 N86-31542
- WILCOX, S. W.**
A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy [AIAA PAPER 86-2029] p 809 A86-47420
- WILLIAMS, D. H.**
Design factors and considerations for a time-based flight management system [AIAA PAPER 86-2144] p 822 A86-47455
- Advanced ATC - An aircraft perspective p 788 A86-49637
- WILLIAMS, M. J.**
A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425
- WILLIAMSON, R. G.**
Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage [ASME PAPER 86-GT-56] p 765 A86-48134
- The effect of a downstream rotor on the measured performance of a transonic turbine nozzle [ASME PAPER 86-GT-103] p 814 A86-48166
- WILSON, D.**
Advanced polymer composites for high temperature applications p 843 A86-49021
- WILSON, R.**
MATRIXx Plus with HYPER-BUILD - Accelerating control design, analysis, and simulation [AIAA PAPER 86-2085] p 853 A86-47505
- WINGARTEN, N. C.**
Effects of time delay and pitch control sensitivity in the flared landing [AIAA PAPER 86-2075] p 831 A86-47706
- WINGROVE, R. C.**
The analysis of airline flight records for winds and performance with application to the Delta 191 accident [AIAA PAPER 86-2227] p 829 A86-47690
- WINTER, J.**
The performance of a reverse flow combustor using JP 10 fuel [ASME PAPER 86-GT-146] p 814 A86-48202
- WINTER, S. J.**
A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy [AIAA PAPER 86-2029] p 809 A86-47420
- WINTUCKY, W. T.**
An overview of the Small Engine Component Technology (SECT) studies [NASA-TM-88796] p 819 N86-31587
- WITT, P. A.**
Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AD-A167717] p 781 N86-31539
- WITTLIN, G.**
KRASH 85 user's guide: Input/output format, revision [AD-A168846] p 787 N86-32416
- WLEZIEN, R. W.**
Passive control of jets with indeterminate origins p 780 A86-49807
- WOLF, D. E.**
Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- WONG, G. A.**
Characteristics of altitude error at reduced quantization [FAA/PM-86/35] p 811 N86-31580
- WOO, A. C.**
Application of the TranAir full-potential code to complete configurations p 772 A86-49009
- WOOD, E. R.**
Implementation and verification of a comprehensive helicopter coupled rotor - Fuselage analysis p 799 A86-48667
- WOOD, M.**
Fabrication of high-alumina ceramic fixtures for jet engine repair applications [ASME PAPER 86-GT-46] p 846 A86-48130
- WOODCOCK, R. J.**
The MIL-prime standard for aircraft flying qualities [AIAA PAPER 86-2131] p 828 A86-47677
- WOODHEAD, M. A.**
Active flutter suppression p 832 A86-49004
- WOOLLEY, D.**
Airports build for future traffic amid new security concern p 838 A86-48371
- WU, C. C.**
Transonic wave drag estimation and optimization using the nonlinear area rule [AIAA PAPER 86-1798] p 778 A86-49582
- WU, W.**
Numerical solution of transonic stream function equation on S1 stream surface in cascade [ASME PAPER 86-GT-110] p 765 A86-48172
- WUENNERBERG, H.**
Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782
- WURZEL, D.**
On the fast repair of aircraft panel components p 782 A86-49066
- WYDRA, G.**
High speed ejection tests of a modified Hybrid III Manikin p 784 A86-47738

X

- XIN, Z.-M.**
A study of stability and control of a hingeless rotor helicopter with non-uniform induced velocity field p 831 A86-48655
- XU, G.**
Numerical analysis of aeroelastic stability problem of helicopter rotor blade p 798 A86-48662
- XU, Y.-X.**
Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659

Y

- YAN, B.**
Calculating method for Z - 9 helicopters mooring load p 799 A86-48668
- YAN, M.**
The dynamic response of a variable sweep aircraft in the course of changing geometry [AIAA PAPER 86-2234] p 829 A86-47694
- YANG, D.**
International Aviation (selected articles) [AD-A166298] p 783 N86-31528
- YANG, L.**
Interior transition layers in flight path optimization [AIAA PAPER 86-2037] p 797 A86-48576
- YANG, S.**
Helicopter parameter identification technology research under the considerably disturbing condition p 831 A86-48670
- YANG, X. T.**
Design of a supercritical airfoil p 771 A86-48982
- YEN, J. G.**
Coupled aeroelastic hub loads reduction p 799 A86-48665
- YEUNG, W.**
Potential flow models of airfoils with separated flow p 772 A86-49013
- YIPING, L.**
A method for transonic inverse cascade design with a stream function equation [ASME PAPER 86-GT-189] p 766 A86-48239
- YONKE, W. A.**
Development of HIDECA adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278
- YOSHIHARA, H.**
PN/S calculations for a fighter W/F at high-lift yaw conditions [AIAA PAPER 86-1829] p 779 A86-49588
- YOUNGBLOOD, D. B.**
The application of energy techniques to propeller-driven airplanes [AD-A167113] p 807 N86-31569

Z

- ZABELIN, I. U. A.**
Wave drag of a supersonic air intake at high subsonic velocities p 770 A86-48834
- ZAEFFEL, K. P.**
A wide bandwidth electrostatic field sensor for lightning research p 850 A86-50260

ZAKHAROV, S. B.

Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779

Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838

ZEILER, T. A.

Integrated structure/control design - Present methodology and future opportunities

p 854 A86-49094

ZENG, Y.

An approach to integrated aeroservoelastic tailoring for stability

p 836 N86-32439

ZHANG, Q.-F.

Precise solution for rational transfer parameters of flight vehicles

p 801 A86-49022

ZHANG, Q.-F.

Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer [ASME PAPER 86-GT-174]

p 815 A86-48225

ZHANG, X.

Some aspects of supersonic flow over a cavity cascade [AIAA PAPER 86-2025]

p 764 A86-47659

ZHANG, X.-G.

The physical understanding on helicopter air and ground resonance

p 798 A86-48660

ZHANG, Z. Y.

Design of a supercritical airfoil

p 771 A86-48982

ZHELEZNIAK, V. N.

The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account

p 770 A86-48833

ZHENG, Q.

Calculating method for Z - 9 helicopters mooring load

p 799 A86-48668

ZHENGJI, Y.

A method for transonic inverse cascade design with a stream function equation [ASME PAPER 86-GT-189]

p 766 A86-48239

ZHONG, L.

International Aviation (selected articles)

[AD-A166298] p 763 N86-31528

ZHOU, Q.-H.

Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer [ASME PAPER 86-GT-174]

p 815 A86-48225

ZHOU, S.

Numerical analysis of aeroelastic stability problem of helicopter rotor blade

p 798 A86-48662

ZHOU, W.

The dynamic response of a variable sweep aircraft in the course of changing geometry [AIAA PAPER 86-2234]

p 829 A86-47694

ZHOU, Z.-G.

The dynamic response of helicopters to fixed wing aircraft wake encounters

p 832 A86-48671

ZHU, D.

Some aspects of the reliability analysis of aircraft structures

p 849 A86-49127

ZHU, D. M.

Research on active suppression technology for wing/aileron flutter

p 835 A86-49096

ZHU, J.-S.

Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis

p 847 A86-48656

ZIMMER, H.

New technology propulsion (ANT) for general aviation aircraft, phase 1 [BMFT-FB-W-85-031]

p 820 N86-31589

ZIMMERMANN, R. E.

Retrofit energy-absorbing crewseat for the SH-3 (S-61 series) Sea King helicopter

p 793 A86-47736

ZINDELUK, M.

Use of acoustic intensity measurements in the characterization of jet noise sources

p 855 A86-48740

ZINN, B. T.

An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight

p 856 A86-49806

ZIV, I.

Frequency and time domain designs of a strapdown vertical determination system [AIAA PAPER 86-2148]

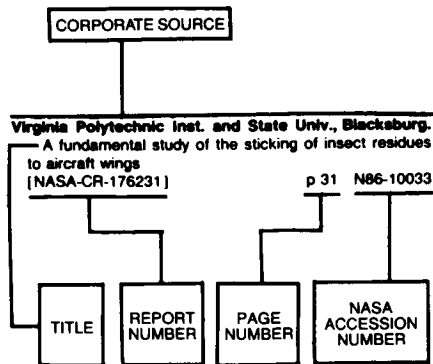
p 810 A86-47457

CORPORATE SOURCE INDEX

AERONAUTICAL ENGINEERING / A Continuing Bibliography (Supplement 208)

January 1987

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

Aeronautical Research Inst. of Sweden, Stockholm.
A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAAB SF 340
[FFA-TN-1986-22] p 856 N86-33125

Aeronautical Research Labs., Melbourne (Australia).
Analysis of a mirror deck landing aid
[AD-A167988] p 789 N86-31556

A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics
[ARL-AERO-TM-379] p 808 N86-32425

Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
An analytical methodology for predicting repair time distributions of advanced technology aircraft
[AD-A167149] p 763 N86-31529

The application of energy techniques to propeller-driven airplanes
[AD-A167113] p 807 N86-31569

On the handling qualities of flight vehicles through variable flight conditions
[AD-A167727] p 836 N86-31592

Air Force Systems Command, Wright-Patterson AFB, Ohio.
International Aviation (selected articles)
[AD-A166298] p 763 N86-31528

Alphatech, Inc., Burlington, Mass.
Simulation results of automatic restructurable flight control system concepts
[AIAA PAPER 86-2032] p 821 A86-47422

Analytical Methods, Inc., Redmond, Wash.
Unsteady low-speed aerodynamic model for complete aircraft configurations
[AIAA PAPER 86-2180] p 829 A86-47683

Arinc Research Corp., Annapolis, Md.
Evaluation of alternatives for an Army precision landing system
[AD-A167780] p 789 N86-31554

Arizona Univ., Tucson.
Angle-of-attack estimation for analysis of CAT encounters
p 831 A86-47798

Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
Aerial refueling evaluation of the CH-47D helicopter
[AD-A167575] p 808 N86-31574

Army Aviation Research and Technology Activity, Cleveland, Ohio.
Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation
[AIAA PAPER 86-1452] p 818 A86-49611

Auburn Univ., Ala.
The effect on the transmission loss of a double wall panel of using helium gas in the gap
p 855 A86-48590

Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions
p 799 A86-48738

Avco Lycoming Div., Williamsport, Pa.
Stratified charge rotary engine for general aviation
[ASME PAPER 86-GT-181] p 815 A86-48231

B

Boeing Commercial Airplane Co., Seattle, Wash.
NASA B737 flight test results of the Total Energy Control System
[AIAA PAPER 86-2143] p 826 A86-47516

Boeing Military Airplane Development, Seattle, Wash.
PN/S calculations for a fighter W/F at high-lift yaw conditions
[AIAA PAPER 86-1829] p 779 A86-49588

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 1: Fire detection, fire extinguishment and surface ignition studies
[AD-A167356] p 807 N86-31570

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 1: Executive summary
[AD-A167443] p 807 N86-31571

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 2: Aircraft engine nacelle fire test programs. Part 2: Small scale testing of dry chemical fire extinguishants
[AD-A167444] p 807 N86-31572

Vulnerability methodology and protective measures for aircraft fire and explosion hazards. Volume 3: On-Board Inert Gas Generator System (OBIGGS) studies. Part 2: Fuel scrubbing and oxygen evolution tests
[AD-A167445] p 807 N86-31573

C

California Univ., Davis.
Boundary-layer transition effects on airplane stability and control
[AIAA PAPER 86-2229] p 831 A86-47708

An entropy correction method for unsteady full potential flows with strong shocks
[AIAA PAPER 86-1768] p 777 A86-49576

California Univ., Los Angeles.
An entropy correction method for unsteady full potential flows with strong shocks
[AIAA PAPER 86-1768] p 777 A86-49576

Calspan Corp., Buffalo, N. Y.
The interpretation of flying qualities requirements for flight control design
[AIAA PAPER 86-2249] p 826 A86-47523

Effects of time delay and pitch control sensitivity in the flared landing
[AIAA PAPER 86-2075] p 831 A86-47706

Carville Ltd., Dorking (England).
An improved optical viewing system for a flight simulator
[MS-8025] p 840 N86-32448

Charles River Analytica, Inc., Cambridge, Mass.
Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors
[AIAA PAPER 86-2030] p 810 A86-47511

Cornell Univ., Ithaca, N.Y.
Broadband noise of propellers and rotors
p 855 A86-48596

D

DEI-Tech, Inc., Newport News, Va.
Flight tests and preliminary aerodynamic parameter extraction of an externally piloted vehicle aircraft model
p 796 A86-47800

Delta Air Lines, Inc., Atlanta, Ga.
Optimization and acceleration guidance of flight trajectories in a windshear
[AIAA PAPER 86-2036] p 822 A86-47425

Optimization and gamma/theta guidance of flight trajectories in a windshear
p 834 A86-49071

Department of the Air Force, Washington, D.C.
Portable glide slope indicator
[AD-D012240] p 789 N86-31552

Multiple thermocouple testing device
[AD-D012276] p 850 N86-31880

Low mass diffusion bonding tools
[AD-D012295] p 851 N86-32746

Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
Servo-actuator for sampled-data feedback disturbance rejection
[DFVLR-FB-86-08] p 837 N86-32446

Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577

New technology propulsion (ANT) for general aviation aircraft, phase 1
[BMFT-FB-W-85-031] p 820 N86-31589

Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
Aircraft control surface failure detection and isolation using the OSGLR test
[AIAA PAPER 86-2028] p 821 A86-47419

Dynetics, Inc., Huntsville, Ala.
Aerodynamics of aircraft afterbody: Report of the working group on aerodynamics of aircraft afterbody
[AGARD-AR-226] p 782 N86-32408

E

Ecole Nationale Supérieure des Arts et Metiers, Bordeaux (France).
Fatigue resistance of high quality steels under multiaxial load
[ETN-86-97878] p 851 N86-32785

Electro Magnetic Applications, Inc., Denver, Colo.
F-106 data summary and model results relative to threat criteria and protection design analysis
p 786 A86-50259

European Space Agency, Paris (France).
Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB)
[ESA-TT-916-PT-2] p 782 N86-31542

Aerodynamic design methods for modern transport aircraft
[ESA-TT-923] p 782 N86-31543

A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations
[ESA-TT-928] p 789 N86-31558

Investigations in landing process of aircraft by means of the Monte-Carlo method
[ESA-TT-951] p 808 N86-31578

User's manual for the Falcon system
[ESA-TT-936] p 808 N86-31579

On control concept for in-flight simulation including actuator nonlinearities and time delays
[ESA-TT-948] p 836 N86-31593

Identification of gust input and gust response characteristics from Do 28 TNT flight test data [ESA-TT-819] p 837 N86-32445

F

Federal Aviation Administration, Atlantic City, N.J.
Loran C 1984 spring-summer stability [AD-A167867] p 789 N86-31555

Federal Aviation Administration, Hampton, Va.
Use of flight simulation to develop terminal instrument procedures for transport category aircraft [AIAA PAPER 86-2072] p 837 A86-47662

Federal Aviation Administration, Washington, D.C.
Advisory Circular: Design considerations to protect fuel systems during a wheels-up landing [FAA-AC/25-994-1] p 806 N86-31564

Characteristics of altitude error at reduced quantization [FAA/PM-86/35] p 811 N86-31580

Airport noise control strategies [AD-A167877] p 840 N86-31802

G

Garrett Turbine Engine Co., Phoenix, Ariz.
Perspectives on dilution jet mixing [AIAA PAPER 86-1611] p 818 A86-49614

General Accounting Office, Washington, D. C.
Air safety: Federal Aviation Administration's role in developing mid-air collision avoidance back-up systems [PB86-197506] p 787 N86-32418

George Washington Univ., Hampton, Va.
Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057

Georgia Inst. of Tech., Atlanta.
An iterative finite element-integral technique for predicting sound radiation from turbofan inlets in steady flight p 856 A86-49806

H

Hamilton Standard, Windsor Locks, Conn.
System design and integration of the large-scale advanced prop-fan [NASA-CR-174789] p 781 N86-31536

I

Informatics General Corp., Palo Alto, Calif.
A knowledge-based expert system for scheduling of airborne astronomical observations p 854 A86-49627

Institut Franco-Allemand de Recherches, St. Louis (France).
Interferometric holographic cinematography [ISL-CO-219/85] p 851 N86-31872

Integrated Systems, Inc., Palo Alto, Calif.
Real-time flutter identification with close mode resolution [AIAA PAPER 86-2019] p 827 A86-47654

A study of aircraft cruise [AIAA PAPER 86-2286] p 792 A86-47704

J

John Deere Technologies International, Inc., Wood-Ridge, N.J.
Stratified charge rotary engine for general aviation [ASME PAPER 86-GT-181] p 815 A86-48231

K

Kansas Univ. Center for Research, Inc., Lawrence.
Preliminary control law and hardware designs for a ride quality augmentation system for commuter aircraft. Phase 2 [NASA-CR-4014] p 836 N86-32440

Kentron International, Inc., Hampton, Va.
Airfoil trailing-edge flow measurements p 780 A86-49803

Koninklijk Inst. voor de Marine, Den Helder (Netherlands).
Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2 [ETN-86-97395] p 811 N86-31581

L

Lightning Technologies, Inc., Pittsfield, Mass.
Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318

Lockheed-California Co., Burbank.
KRASH 85 user's guide: Input/output format, revision [AD-A168846] p 787 N86-32418

M

Massachusetts Inst. of Tech., Cambridge.
Aircraft control surface failure detection and isolation using the OSGLR test [AIAA PAPER 86-2028] p 821 A86-47419

Analytical and experimental investigation of the coupled bladed disk/shaft whirl of a cantilevered turbofan [ASME PAPER 86-GT-98] p 813 A86-48163

McDonnell Aircraft Co., St. Louis, Mo.
Development of HIDECA adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278

Minnesota Univ., Minneapolis.
Design of a multivariable flutter control/gust load alleviation system [AIAA PAPER 86-2247] p 825 A86-47494

N

National Aeronautical Lab., Bangalore (India).
A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure [NAL-TRM-SE-8603] p 782 N86-32393

Six degree of freedom simulation software [NAL-PD-SE-8614] p 854 N86-33042

National Aeronautics and Space Administration, Washington, D.C.
Mission adaptive wing soars at NASA Facility [P86-10182] p 806 N86-31563

National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.
Rotary-wing aircraft terrain-following/terrain-avoidance system development [AIAA PAPER 86-2147] p 823 A86-47456

Performance characteristics of an adaptive controller based on least-mean-square filters [AIAA PAPER 86-2160] p 852 A86-47466

Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495

A robust adaptive flightpath reconstruction technique [AIAA PAPER 86-2018] p 826 A86-47653

Flight evaluation of a precision landing task for a powered-lift STOL aircraft [AIAA PAPER 86-2130] p 828 A86-47676

Unsteady low-speed aerodynamic model for complete aircraft configurations [AIAA PAPER 86-2180] p 829 A86-47683

The analysis of airline flight records for winds and performance with application to the Delta 191 accident [AIAA PAPER 86-2227] p 829 A86-47690

The ground effects of a powered-lift STOL aircraft during landing approach p 795 A86-47784

Angle-of-attack estimation for analysis of CAT encounters p 831 A86-47798

Application of the TranAir full-potential code to complete configurations p 772 A86-49009

A study of helicopter main rotor noise in hover [AIAA PAPER 86-1858] p 856 A86-49575

Rotor tip vortex geometry measurements using the wide-field shadowgraph technique [AIAA PAPER 86-1780] p 778 A86-49580

PN/S calculations for a fighter W/F at high-lift yaw conditions [AIAA PAPER 86-1829] p 779 A86-49588

A knowledge-based expert system for scheduling of airborne astronomical observations p 854 A86-49627

Recent developments in rotary-wing aerodynamic theory p 780 A86-49802

Transonic airfoil calculations including wind tunnel wall-interference effects p 780 A86-49825

Elliptic generation of composite three-dimensional grids about realistic aircraft [NASA-TM-88240] p 763 N86-31527

ATRAN3S: An unsteady transonic code for clean wings [NASA-TM-86783] p 781 N86-31535

Simulation evaluation of display/FLIR concepts for low-altitude, terrain-following helicopter operations [NASA-TM-86779] p 789 N86-31551

High speed viscous flow calculations about complex configurations [NASA-TM-88237] p 850 N86-31827

Transonic Navier-Stokes wing solutions using a zonal approach. Part 2: High angle-of-attack simulation [NASA-TM-88248-PT-2] p 782 N86-32392

Simulator scene display evaluation device [NASA-CASE-ARC-11504-1] p 840 N86-32447

National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.
Effect of time delay on flying qualities - An update [AIAA PAPER 86-2202] p 823 A86-47482

Flight control system development and flight test experience with the F-111 mission adaptive wing aircraft [AIAA PAPER 86-2237] p 824 A86-47489

Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft [AIAA PAPER 86-2243] p 824 A86-47491

Model-following control for an oblique-wing aircraft [AIAA PAPER 86-2244] p 824 A86-47492

Real-time flutter identification with close mode resolution [AIAA PAPER 86-2019] p 827 A86-47654

Application of parameter estimation to highly unstable aircraft [AIAA PAPER 86-2020] p 827 A86-47655

Validation of a new flying quality criterion for the landing task [AIAA PAPER 86-2126] p 828 A86-47672

Flight test experience and controlled impact of a large, four-engine remotely piloted airplane p 794 A86-47781

Flight flutter testing at Ames-Dryden p 797 A86-47802

Development of HIDECA adaptive engine control systems [ASME PAPER 86-GT-252] p 816 A86-48278

National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
Research in lightning swept-stroke attachment patterns and flight conditions with the NASA F-106B airplane p 791 A86-47318

Time scale analysis of a closed-loop discrete optimal control system [AIAA PAPER 86-1995] p 852 A86-47417

Simulation results of automatic restructurable flight control system concepts [AIAA PAPER 86-2032] p 821 A86-47422

Evaluation of total energy-rate feedback for glidescope tracking in wind shear [AIAA PAPER 86-2035] p 822 A86-47424

Design factors and considerations for a time-based flight management system [AIAA PAPER 86-2144] p 822 A86-47455

Design considerations for flight test of a fault inferring nonlinear detection system algorithm for avionics sensors [AIAA PAPER 86-2030] p 810 A86-47511

NASA B737 flight test results of the Total Energy Control System [AIAA PAPER 86-2143] p 826 A86-47516

The interpretation of flying qualities requirements for flight control design [AIAA PAPER 86-2249] p 826 A86-47523

Composites in today's and tomorrow's U.S. airliners p 841 A86-47603

Use of flight simulation to develop terminal instrument procedures for transport category aircraft [AIAA PAPER 86-2072] p 837 A86-47662

Pilot evaluation of experimental flight trajectories in the near-terminal area [AIAA PAPER 86-2074] p 838 A86-47664

Effects of time delay and pitch control sensitivity in the flared landing [AIAA PAPER 86-2075] p 831 A86-47706

Boundary-layer transition effects on airplane stability and control [AIAA PAPER 86-2229] p 831 A86-47708

An artificial intelligence approach to onboard fault monitoring and diagnosis for aircraft applications [AIAA PAPER 86-2093] p 853 A86-48577

Investigation of the level difference between sound pressure and sound intensity in an aircraft cabin under different fuselage conditions p 799 A86-48738

The impact of emerging technologies on an advanced supersonic transport p 761 A86-48997

Flight management concepts compatible with air traffic control p 788 A86-49018

Algebraic grid generation about wing-fuselage bodies p 772 A86-49028

Experimental study of effects of forebody geometry on high angle of attack static and dynamic stability and control p 833 A86-49039

Forebody vortex management for yaw control at high angles of attack p 833 A86-49047

- Structural dynamics research in a full-scale transport aircraft crash test p 785 A86-49053
- Estimation of aerodynamic parameters from flight data of a high incidence research model p 834 A86-49057
- Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- Applications of potential theory computations to transonic aerelasticity p 775 A86-49105
- Topics in landing gear dynamics research at NASA Langley p 803 A86-49120
- Wing laminar boundary layer in the presence of a propeller slipstream p 776 A86-49122
- An entropy correction method for unsteady full potential flows with strong shocks [AIAA PAPER 86-1768] p 777 A86-49576
- High-angle-of-attack aerodynamics - Lessons learned [AIAA PAPER 86-1774] p 777 A86-49578
- Flowfield survey over a 75 deg swept delta wing at an angle of attack of 20.5 deg [AIAA PAPER 86-1775] p 777 A86-49579
- A new, improved method for separating turbulent boundary layer for aerodynamic performance prediction of trailing edge stall airfoils [AIAA PAPER 86-1832] p 779 A86-49590
- Advanced ATC - An aircraft perspective p 788 A86-49637
- Airfoil trailing-edge flow measurements p 780 A86-49803
- Implicit hybrid schemes for the flux-difference split, three-dimensional Navier-Stokes equations p 850 A86-50258
- F-106 data summary and model results relative to threat criteria and protection design analysis p 788 A86-50259
- A wide bandwidth electrostatic field sensor for lightning research p 850 A86-50260
- Laminar flow research applicable to subsonic aircraft p 781 A86-50269
- Low-speed aerodynamic characteristics of a 1/8-scale X-29A airplane model at high angles of attack and sideslip [NASA-TM-87722] p 781 A86-51352
- Flight test of passive wing/store flutter suppression [NASA-TM-87766] p 806 A86-51568
- Development of a takeoff performance monitoring system [NASA-TM-89001] p 835 A86-51591
- National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.**
- Computational engine structural analysis [ASME PAPER 86-GT-70] p 813 A86-48141
- Toward improved durability in advanced combustors and turbines - Progress in prediction of thermomechanical loads [ASME PAPER 86-GT-172] p 815 A86-48224
- Stratified charge rotary engine for general aviation [ASME PAPER 86-GT-181] p 815 A86-48231
- NASA's aircraft icing analysis program p 786 A86-49107
- Unified constitutive materials model development and evaluation for high-temperature structural analysis applications p 849 A86-49133
- An approach to the calculation of the pressure field produced by rigid wide chord dual rotation propellers of high solidity in compressible flow [AIAA PAPER 86-0467] p 856 A86-49566
- Plume characteristics of single-stream and dual-flow conventional and inverted-profile nozzles at equal thrust [AIAA PAPER 86-1809] p 778 A86-49585
- Small gas turbine combustor experimental study - Compliant metal/ceramic liner and performance evaluation [AIAA PAPER 86-1452] p 818 A86-49611
- Perspectives on dilution jet mixing [AIAA PAPER 86-1611] p 818 A86-49614
- Preliminary results of unsteady blade surface pressure measurements for the SR-3 propeller [AIAA PAPER 86-1893] p 780 A86-49625
- NASA's Aircraft Icing Analysis Program [NASA-TM-88791] p 786 A86-51548
- In-flight photogrammetric measurement of wing ice accretions [NASA-TM-87191] p 806 A86-51562
- Small gas turbine combustor experimental study: Compliant metal/ceramic liner and performance evaluation [NASA-TM-87304] p 819 A86-51582
- Aeropropulsion opportunities for the 21st century [NASA-TM-88817] p 819 A86-51585
- A parametric study of a gas-generator air turbo ramjet (ATR) [NASA-TM-88808] p 819 A86-51586
- An overview of the Small Engine Component Technology (SECT) studies [NASA-TM-88796] p 819 A86-51587

- Turbulent dispersion of the icing cloud from spray nozzles used in icing tunnels [NASA-TM-87316] p 820 A86-51588
- National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.**
- Recent advances in Monte Carlo turbulence simulation p 792 A86-47836
- National Aerospace Lab., Amsterdam (Netherlands).**
- Computations of separated subsonic and transonic flow about airfoils in unsteady motion [NLR-MP-84094-U] p 782 A86-51541
- Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system [NPL-VG-84-009-L] p 789 A86-52419
- The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques [NLR-TR-85014-U] p 809 A86-52430
- Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program [NLR-MP-84023-U] p 811 A86-52431
- TURBISTAN: A standard load sequence for aircraft engine disks [NLR-MP-85033-U] p 820 A86-52436
- Recent developments in propulsion aerodynamics [NLR-MP-85031-U] p 820 A86-52437
- Cost reductions from introduction of new life philosophies for aircraft engine discs [NLR-MP-85076-U] p 820 A86-52438
- Review of aeronautical fatigue investigations in the Netherlands during the period March 1983 - February 1985 [NLR-MP-85025-U] p 851 A86-52779
- Short cracks in aerospace structures [NLR-MP-85054-U] p 851 A86-52781
- Simulation and optimization techniques in computer aided design [NLR-MP-85022-U] p 854 A86-53053
- An infrastructure for information processing for computer aided design [NLR-MP-85038-U] p 854 A86-53054
- Naval Postgraduate School, Monterey, Calif.**
- Development of a data acquisition system to aid in the aerodynamic study of various helicopter configurations [AD-A167717] p 781 A86-51539
- A trade-off study of tilt rotor aircraft versus helicopters using VASCOMP 2 and HESCOMP [AD-A167719] p 808 A86-51575
- Design of a vertical thrust stand for a remotely piloted model helicopter [AD-A167811] p 840 A86-51598
- Survivability considerations during aircraft conceptual design [AD-A168555] p 809 A86-52428
- Naval Underwater Systems Center, New London, Conn.**
- Measurement and extraction of recurring waveforms: For applications to active transmissions, flow-noise, and helicopter-radiated noise problems [AD-A167400] p 856 A86-52249
- North Carolina State Univ., Raleigh.**
- Forebody vortex management for yaw control at high angles of attack p 833 A86-49047

O

- Office National d'Etudes et de Recherches Aeronautiques, Paris (France).**
- Dynamic identification procedure and lift certification of light aircraft and gliders [ONERA-RT-12/1677-RY-080-R] p 809 A86-52429
- Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA [ONERA-RT-19/3463-AYP] p 841 A86-52451
- Old Dominion Univ., Norfolk, Va.**
- Finite-volume and integral-equation techniques for transonic and supersonic vortex-dominated flows p 774 A86-49045

P

- PRC Kentron, Inc., Hampton, Va.**
- Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- Princeton Univ., N. J.**
- Aeroelastic behavior of low aspect ratio metal and composite blades [ASME PAPER 86-GT-243] p 846 A86-48271
- Optimal control laws for microburst encounter p 834 A86-49070
- Purdue Univ., West Lafayette, Ind.**
- On the flight dynamics of aeroelastic vehicles [AIAA PAPER 86-2077] p 828 A86-47666

University of Western Michigan, Kalamazoo.

- Splitter blades as an aeroelastic detuning mechanism for unstalled supersonic flutter of turbomachine rotors [ASME PAPER 86-GT-99] p 813 A86-48164
- Integrated structure/control design - Present methodology and future opportunities p 854 A86-49094
- Flight control synthesis for flexible aircraft using Eigenspace assignment [NASA-CR-178164] p 835 A86-51590
- An approach to integrated aeroservoelastic tailoring for stability p 836 A86-52439

R

- Rice Univ., Houston, Tex.**
- Optimization and acceleration guidance of flight trajectories in a windshear [AIAA PAPER 86-2036] p 822 A86-47425
- Optimization and gamma/theta guidance of flight trajectories in a windshear p 834 A86-49071
- Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.**
- On the way to extended noise reductions in propeller aircraft [B8573697] p 857 A86-53126

S

- Sandia National Labs., Albuquerque, N. Mex.**
- Airborne intruder detection considerations [DE86-006462] p 808 A86-51576
- Science Applications International Corp., Princeton, N.J.**
- Parabolized Navier-Stokes analysis of three-dimensional supersonic and subsonic jet mixing problems p 780 A86-49804
- Societe Nationale Industrielle Aerospatiale, Paris (France).**
- Anemobarometry in flight control. A-320 aerodynamics. The turboreactors air inlet [SNIAS-861-111-114] p 806 A86-51565
- Anemobarometry: An essential element of flight control p 835 A86-51566
- The A-320 aerodynamics. The turboreactor air inlet [NOTE-427.021/86] p 806 A86-51567
- Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter [SNIAS-861-210-108] p 836 A86-52444
- Societe Nationale Industrielle Aerospatiale, Toulouse (France).**
- Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners) [SNIAS-436.021/85] p 851 A86-52784
- Stanford Univ., Calif.**
- Optimal landing of a helicopter in autorotation [AIAA PAPER 86-2287] p 793 A86-47705
- Sverdrup Technology, Inc., Cleveland, Ohio.**
- Unified constitutive materials model development and evaluation for high-temperature structural analysis applications p 849 A86-49133

T

- Technion - Israel Inst. of Tech., Haifa.**
- Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms [AIAA PAPER 86-2248] p 825 A86-47495
- Test Wing (4950th), Wright-Patterson AFB, Ohio.**
- Fireproof hydraulic brake system [AD-A167774] p 786 A86-51549
- Texas A&M Univ., College Station.**
- An experimental study of a three lifting surface configuration p 775 A86-49104
- Wing laminar boundary layer in the presence of a propeller slipstream p 776 A86-49122

U

- United Technologies Research Center, East Hartford, Conn.**
- Overview of helicopter wake and airloads technology p 767 A86-48654
- University of Western Michigan, Kalamazoo.**
- Eigensystem synthesis for active flutter suppression on an oblique-wing aircraft [AIAA PAPER 86-2243] p 824 A86-47491
- Model-following control for an oblique-wing aircraft [AIAA PAPER 86-2244] p 824 A86-47492

V

VDO-Luftfahrtgeraete Werk Adolf Schindling G.m.b.H.,
Frankfurt (West Germany).

Studies for the application of a flexible weight and
balance (W/B) measuring facility for commercial aircraft
[BMFT-FB-W-85-029] p 840 N86-31604

Vigyan Research Associates, Inc., Hampton, Va.

Forebody vortex management for yaw control at high
angles of attack p 833 A86-49047

A new, improved method for separating turbulent
boundary layer for aerodynamic performance prediction
of trailing edge stall airfoils

[AIAA PAPER 86-1832] p 779 A86-49590

Virginia Polytechnic Inst. and State Univ., Blacksburg.

Noise control characteristics of synchrophasing. II -

Experimental investigation p 805 A86-49808

Aspect ratio effects on wings at low Reynolds
numbers p 782 N86-32390

W

Westland Helicopters Ltd., Yeovil (England).

Dynamic analysis: Correlation of theory with
experiment

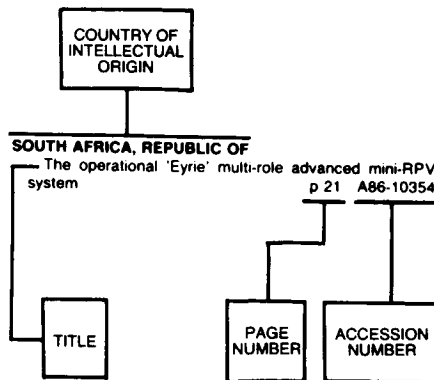
[RP661] p 851 N86-31917

Wichita State Univ., Kans.

Weight estimation techniques for composite airplanes
in general aviation industry

[NASA-CR-178163] p 781 N86-31531

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section.

A

ARGENTINA

Wind influence on the range of jet or propeller aircraft
p 801 A86-48990

AUSTRALIA

Proposed control of compressor stall by pressure perturbation and blade design p 816 A86-49064
Analysis of a mirror deck landing aid [AD-A167988] p 789 N86-31556
A mathematical model of the Sea King Mk.50 helicopter aerodynamics and kinematics [ARL-AERO-TM-379] p 808 N86-32425

AUSTRIA

Can future aircraft maintenance be afforded?
p 857 A86-47617

B

BRAZIL

Use of acoustic intensity measurements in the characterization of jet noise sources
p 855 A86-48740

C

CANADA

Helicopter IFR director algorithm development and flight evaluation on the NAE airborne simulator [AIAA PAPER 86-2205] p 787 A86-47519
The effect of heave damping (ZW) on helicopter handling qualities [AIAA PAPER 86-2129] p 828 A86-47675
Scott emergency escape breathing device - Evaluation for use in Canadian forces aircraft p 784 A86-47731
Power turbine vane ring (PT6 engine) repair development [ASME PAPER 86-GT-2] p 812 A86-48102

Influence of rotor blade aerodynamic loading on the performance of a highly loaded turbine stage [ASME PAPER 86-GT-56] p 765 A86-48134
The effect of a downstream rotor on the measured performance of a transonic turbine nozzle [ASME PAPER 86-GT-103] p 814 A86-48166
Combustion gas properties. II - Prediction of partial pressures of CO₂ and H₂O in combustion gases of aviation and diesel fuels [ASME PAPER 86-GT-163] p 843 A86-48216
Thick supercritical airfoils with low drag and NLF capability p 771 A86-48981
Potential flow models of airfoils with separated flow p 772 A86-49013
A study of the structural integrity of the Canadair Challenger at ditching p 785 A86-49054
Analysis of wind tunnel corrections for half-model tests of a transport aircraft using a doublet panel method p 839 A86-49060

CHINA, PEOPLE'S REPUBLIC OF

Aircraft maintenance in China - Approaches to modernization p 760 A86-47615
The dynamic response of a variable sweep aircraft in the course of changing geometry [AIAA PAPER 86-2234] p 829 A86-47694
Numerical solution of transonic stream function equation on S1 stream surface in cascade [ASME PAPER 86-GT-110] p 765 A86-48172
Impaction efficiencies of evaporating kerosene droplets on vee-gutter flame stabilizer [ASME PAPER 86-GT-174] p 815 A86-48225
A method for transonic inverse cascade design with a stream function equation [ASME PAPER 86-GT-189] p 766 A86-48239
The helicopter technology of China p 761 A86-48652
A study of the rotor wake in nap-of-the-earth p 767 A86-48653
A study of stability and control of a hingeless rotor helicopter with non-uniform induced velocity field p 831 A86-48655
Finite element analysis and optimum design of semi-monocoque airframe structures. I - Finite element analysis p 847 A86-48656
Program system of computer-aided design of helicopter rotor blade airfoil p 798 A86-48659
The physical understanding on helicopter air and ground resonance p 798 A86-48660
Numerical analysis of aeroelastic stability problem of helicopter rotor blade p 798 A86-48662
Calculating method for Z - 9 helicopters mooring load p 799 A86-48668
Use and maintenance of helicopters on the plateau p 785 A86-48669
Helicopter parameter identification technology research under the considerably disturbing condition p 831 A86-48670
Design of a supercritical airfoil p 771 A86-48982
Precise solution for rational transfer parameters of flight vehicles p 801 A86-49022
Manufacturing technology of composite torque box of vertical fin p 848 A86-49068
Experimental investigation of electrostatic fire and explosion accidents after aircraft landing and preventive design p 786 A86-49083
Research on active suppression technology for wing/aileron flutter p 835 A86-49096
Intersection of an oblique shock wave with a cylindrical afterbody p 775 A86-49098
Some aspects of the reliability analysis of aircraft structures p 849 A86-49127
International Aviation (selected articles) [AD-A166298] p 763 N86-31528

CZECHOSLOVAKIA

Validation on nonstationary aerodynamics models for longitudinal aeroplane motion on the basis of flight measurements p 833 A86-49026
A contribution to airworthiness certification of gas turbine disks p 849 A86-49136
Selection of fatigue S-N curves within the framework of new aircraft development p 804 A86-49137

Safe service life scattering coefficient j sub N (and/or eta sub 4) and the S-N curve p 804 A86-49138
Design of a nonlinear lever-type mechanism for aircraft control systems p 835 A86-49139
Strain-gauge autopilot altitude corrector p 811 A86-49142
Experience with stress analysis during airframe fatigue tests p 840 A86-49143
Application of strain gauge amplifiers and computer technology to the strength testing of aircraft p 849 A86-49144
Contactless measurement of the torque of an aircraft engine p 849 A86-49145
Practical applications of Tesla semiconductor pressure sensors p 849 A86-49148
Application of strain gauge methods to determination of in-flight loads of structure groups of small transport aircraft p 811 A86-49149

F

FRANCE

International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congress International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings p 844 A86-47292
Induced surface currents and fields on a conducting body by a lightning strike (frequency domain) p 844 A86-47296
Induced current surface density after a direct lightning strike on an aircraft p 790 A86-47297
Location of lightning strokes on aircraft in storm field with measured electrical, microphysical and dynamical properties p 783 A86-47299
High voltage laboratory tests and lightning phenomena p 844 A86-47312
New methods for in-flight vibration testing p 820 A86-47369
Digitalization of avionics in today's and tomorrow's aircraft and implications on aircraft maintenance p 760 A86-47609
Practical implementation of a maintenance and engineering system in an airline p 760 A86-47610
Development of a new lightweight emergency escape breathing device p 784 A86-47760
Power level influence on architecture of small helicopter turboshaft engines [ASME PAPER 86-GT-191] p 815 A86-48241
Evaluation and reduction of drag [AAAF PAPER NT 85-01] p 766 A86-48452
Transition to three-dimensional flow and laminarization of the boundary layer on a swept-back wing [AAAF PAPER NT 85-03] p 766 A86-48454
Reduction of turbulent drag - Turbulence manipulators [AAAF PAPER NT 85-04] p 766 A86-48455
Tests on CAST 7 and CAST 10 profiles in the T2 adaptive-wall cryogenic wind tunnel - Study of the Reynolds-number effect in natural and triggered transitions [AAAF PAPER NT 85-06] p 838 A86-48457
Theoretical and experimental analysis of separations on helicopter fuselages [AAAF PAPER NT 85-08] p 766 A86-48458
Unsteady aerodynamics - Fundamental aspects and applications to aircraft dynamics [AAAF PAPER NT 85-16] p 767 A86-48465
Dynamic response of the A.310 in flight to control-surface loading [AAAF PAPER NT 85-18] p 797 A86-48467
Identification of unsteady response in rudders at low velocities [AAAF PAPER NT 85-19] p 797 A86-48468
Analysis and simulation of the MLS landing signal - Echo separation p 788 A86-48564
A parallel processing method for solving the unsteady Navier-Stokes equations at high Reynolds numbers p 847 A86-48647
Computing codes for development of helicopter crashworthy structures and test substantiation p 798 A86-48657

- Aeroelasticity today and tomorrow
[ONERA, TP NO. 1986-105] p 800 A86-48978
- The race for speed from the beginning of aviation to the present day p 761 A86-48980
- Leading edge vortex flow over a 75 degree-swept delta wing Experimental and computational results
[ONERA, TP NO. 1986-122] p 773 A86-49042
- The F2 wind tunnel of the Fauga-Mauzac Test Center
[ONERA, TP NO. 1986-104] p 839 A86-49075
- Single crystal superalloys for turbine blades in advanced aircraft engines
[ONERA, TP NO. 1986-102] p 843 A86-49077
- The M53 turbofan control system - A strong basis for the development of the future digital control systems p 817 A86-49088
- Steady and unsteady investigations of spoiler and flap aerodynamics in two dimensional subsonic flows
[ONERA, TP NO. 1986-101] p 776 A86-49106
- New design procedures applied to landing gear development p 803 A86-49117
- Prediction of single-rotation prop-fan noise by a frequency domain scheme
[ONERA, TP NO. 1986-100] p 818 A86-49125
- Recent in-flight data and electromagnetic response of an aircraft structure struck by lightning p 804 A86-49132
- Design bureaus: The brain drainers. I - Toulouse - Aircraft mobilize a task force over 1700-strong p 763 A86-49464
- Vortex influence on oscillating airfoil at high angle-of-attack
[AIAA PAPER 86-1837] p 779 A86-49592
- Computation of the potential flow over airfoils with cusped or thin trailing edges p 780 A86-49823
- Anemobarometry in flight control. A-320 aerodynamics. The turbochargers air inlet
[SNIAS-861-111-114] p 806 N86-31565
- Anemobarometry: An essential element of flight control p 835 N86-31566
- The A-320 aerodynamics. The turbocharger air inlet
[NOTE-427.021/86] p 806 N86-31567
- On control concept for in-flight simulation including actuator nonlinearities and time delays
[ESA-TT-948] p 836 N86-31593
- Interferometric holographic cinematography
[ISL-CO-219/85] p 851 N86-31872
- Aerodynamics of aircraft afterbody: Report of the working group on aerodynamics of aircraft afterbody
[AGARD-AR-226] p 782 N86-32408
- Dynamic identification procedure and lift certification of light aircraft and gliders
[ONERA-RT-12/1677-RY-090-R] p 809 N86-32429
- Active control of helicopter vibrations. Flight evaluation of a vibration reduction system on a Gazelle SA 349 helicopter
[SNIAS-861-210-108] p 836 N86-32444
- Microphone probe tests in the S3CH wind tunnel for transonic propeller measurements in S1MA
[ONERA-RT-19/3463-APP] p 841 N86-32451
- Computation of the stress intensity factor in stiffened panels (built in or adhesive bonded stiffeners)
[SNIAS-436.021/85] p 851 N86-32784
- Fatigue resistance of high quality steels under multiaxial load
[ETN-86-97878] p 851 N86-32785

G

GERMANY, FEDERAL REPUBLIC OF

- Electromagnetic interaction of external impulse fields with aircraft p 790 A86-47295
- Special protection circuits against transient currents for aircraft systems p 791 A86-47326
- Lightning stroke tests at the CFRP horizontal stabilizer of alpha jet p 792 A86-47331
- Live tests on static electricity in fuelling of aircraft p 783 A86-47334
- AIRMEC '85 - Aviation equipment servicing: Aircraft and helicopter maintenance; International Exhibition and Conference, 4th, Dusseldorf, West Germany, February 26-March 3, 1985, Conference Reports p 759 A86-47601
- A round-up on CFRP p 841 A86-47602
- Potential of BITE's and what it means to aircraft maintenance p 759 A86-47607
- Early corrosion detection and prevention measures p 760 A86-47612
- Anthropometric conditions for the construction of a helicopter cockpit p 794 A86-47768
- Obstacle warning radar for helicopters - An anthropotechnical problem p 787 A86-47769
- Flight testing a transonic wing with maneuver flaps and a direct side force control system for CAS aircraft p 794 A86-47782

- Flight testing of the Tornado Terrain Following Radar System in bad weather p 795 A86-47783
- Results of technology programs for general aviation aircraft at Dornier p 795 A86-47787
- Analysis of the costs and weight effects of CFK on air transport structure p 842 A86-48097
- Comparison of methods for lifetime calculations of highly loaded aero-engine discs
[ASME PAPER 86-GT-102] p 814 A86-48165
- Premixing gas and air to reduce NOx emissions with existing proven gas turbine combustion chambers
[ASME PAPER 86-GT-157] p 814 A86-48211
- An approach to an integrated control system for a modern fighter aircraft engine
[ASME PAPER 86-GT-277] p 816 A86-48296
- Aircraft/engine integration for an advanced fighter considering mission specifics
[ASME PAPER 86-GT-295] p 797 A86-48308
- Measurement of the pressure coefficient at a square wing in transonic-supersonic flows and comparison with theoretical results p 787 A86-48568
- Dynamic aspects in the design of advanced rotor systems p 798 A86-48663
- Handling qualities and flight performance - Implication of the operational envelope p 799 A86-48672
- Investigations on high Reynolds number laminar flow airfoils p 771 A86-48983
- Influence of EFCS-control laws on structural design of modern transport aircraft p 800 A86-48984
- Fibre optic damage detection in composite structures p 848 A86-48988
- Fire safety investigations for material selection and design of a carbon fibre reinforced fuselage structure p 785 A86-48989
- Reducing fuel consumption by cyclic control p 832 A86-48991
- Airbus-assembly concepts to improve productivity and flexibility in aircraft construction p 781 A86-48999
- Efficient solution of three-dimensional Euler equations using embedded grids p 771 A86-49007
- Optimum-Optimum integrated wing-fuselage configuration for supersonic transport aircraft of second generation p 801 A86-49010
- Low cost inertial reference system based on fiber gyros with GPS-aiding p 788 A86-49016
- Test and flight evaluation of precision distance measuring equipment p 788 A86-49017
- Design criteria for flight control systems p 833 A86-49023
- Flight path reconstruction - A powerful tool for data compatibility check p 833 A86-49041
- Aeroacoustics at the German-Dutch wind tunnel p 839 A86-49061
- On the fast repair of aircraft panel components p 762 A86-49066
- Automated systems for the manufacture of Airbus Vertical Stabilizer Spar box in composite materials p 762 A86-49067
- Take-off and landing in a downburst p 786 A86-49069
- Flow field study on a supercritical airfoil using a pressure probe and a two-component Laser-Doppler-Anemometer p 775 A86-49074
- Aeroelastic tailoring for flutter constraints p 802 A86-49081
- Performance evaluation of a linear recursive technique for aircraft altitude prediction in airborn collision avoidance systems p 811 A86-49085
- Digital engine control units for an fighter engine and an auxiliary power unit - A comparison p 817 A86-49089
- Propfan and turbofan - Antagonism or synthesis p 817 A86-49092
- The prediction of lift inferred from downstream vorticity measurements p 775 A86-49102
- On the computation of wing lift interference caused by high bypass engines p 776 A86-49109
- Regression rate study for a solid fuel ramjet p 818 A86-49113
- Shimmy problems of landing gears caused by elastic deformation of tires p 803 A86-49118
- Take-off prediction for the Airbus A300-600 and the A310 compared with flight test results p 804 A86-49121
- Modern developments in rotorcraft technology
[MBB-UD-458-85-OE] p 805 A86-49509
- BK 117 flight tests for certification of an expanded flight envelope
[MBB-UD-452-85-OE] p 805 A86-50253
- Applications of thermal imager devices incl. modelling aspects
[MBB-UD-462-85-OE] p 850 A86-50254
- Development of the BO 105 LS
[MBB-UD-456-85-OE] p 805 A86-50255
- Structural design and analysis aspects of composite helicopter components
[MBB-UD-454-85-OE] p 806 A86-50256

- Aircraft protection against lightning strikes p 806 A86-50347
- Design of a basic profile for a slightly swept wing. Part 2: Experimental investigation on the airfoil DFVLR-W1 in the Brunswick Transonic Wind Tunnel (TWB)
[ESA-TT-916-PT-2] p 782 N86-31542
- Aerodynamic design methods for modern transport aircraft
[ESA-TT-923] p 782 N86-31543
- A feasibility study for the use of electronic flight strips in Air Traffic Control (ATC) controller workstations
[ESA-TT-928] p 789 N86-31558
- Technology demonstration for investigation of the new possibilities of amphibious flying boats, phase 2
[BMFT-FB-W-85-022] p 808 N86-31577
- Investigations in landing process of aircraft by means of the Monte-Carlo method
[ESA-TT-951] p 808 N86-31578
- User's manual for the Falcon system
[ESA-TT-936] p 808 N86-31579
- New technology propulsion (ANT) for general aviation aircraft, phase 1
[BMFT-FB-W-85-031] p 820 N86-31589
- Studies for the application of a flexible weight and balance (W/B) measuring facility for commercial aircraft
[BMFT-FB-W-85-029] p 840 N86-31604
- Identification of gust input and gust response characteristics from Do 28 TNT flight test data
[ESA-TT-919] p 837 N86-32445
- Servo-actuator for sampled-data feedback disturbance rejection
[DFVLR-FB-86-08] p 837 N86-32446

H

HUNGARY

- Method for determining the ISO-noise levels by simulated aircraft flight operations p 856 A86-49099
- Load examination of vehicle-body of reinforced cylindrical shell in case of kinematic load p 849 A86-49128

I

INDIA

- A low speed tunnel semi-free dynamic flying study of the high angle of attack pitch derivatives of HF-24 using MLE procedure
[NAL-TRM-SE-8603] p 782 N86-32393
- Six degree of freedom simulation software
[NAL-PD-SE-8614] p 854 N86-33042
- INTERNATIONAL ORGANIZATION**
- How one A/C manufacturer transits to composites p 759 A86-47604
- Airbus A 320 - New concept of aircraft control p 796 A86-47797
- A simulation facility for assessing the next generation of 4-D air traffic control procedures p 788 A86-49034
- Avionics fault data acquisition - A concept for civil transport aircraft p 810 A86-49051

ISRAEL

- Frequency and time domain designs of a strapdown vertical determination system
[AIAA PAPER 86-2148] p 810 A86-47457
- Adaptive filtering of biodynamic stick feedthrough in manipulation tasks on board moving platforms
[AIAA PAPER 86-2248] p 825 A86-47495
- Concept of automated aircraft guidance system for air-to-air missions
[AIAA PAPER 86-2285] p 787 A86-47703
- Near-optimal feedback control for three-dimensional interceptions p 854 A86-48992
- Effects of spanwise blowing on pressure distribution and leading-edge vortex stability p 774 A86-49046
- Analysis of strake-slender-wing configurations using slender-wing theory p 774 A86-49049
- Theoretical considerations of the specific impulse of ramjet engines p 817 A86-49111
- On the motion of spray drops in the wake of an agricultural aircraft p 777 A86-49441

ITALY

- Stripping and painting a plane - Technological and economic aspects p 760 A86-47614
- Development of an experimental correlation for transonic turbine flow
[ASME PAPER 86-GT-108] p 765 A86-48170
- Analytical and experimental investigation on advanced composite wing box structures in bending including effects of initial imperfections and crushing pressure p 848 A86-49003
- Evaluation of pressure distributions on an aircraft by two different panel methods and comparison with experimental measurements p 774 A86-49044

Control of interior noise in advanced turbopropeller aircraft p 802 A86-49100

J

JAPAN

Synthesis of an adaptive flight controller under unknown deterministic disturbances p 823 A86-47464
[AIAA PAPER 86-2157]
Identification of pilot dynamics in a system with a choice of feedback structures p 825 A86-47496
[AIAA PAPER 86-2250]
A theoretical solution of three-dimensional flows in subsonic, transonic and supersonic turbomachines - An exact solution and its numerical method p 765 A86-48173
[ASME PAPER 86-GT-111]
A study on NOx emissions from gas turbine combustor p 814 A86-48220
[ASME PAPER 86-GT-188]
Optimum design technique for rotating wheels p 846 A86-48261
[ASME PAPER 86-GT-255]
Lighter-than-air aircraft as control configured vehicle p 801 A86-48998
Configuration and trajectory of hypersonic transport with aerothermodynamic control p 804 A86-49124
Calculations of high speed propeller performances using finite difference methods p 818 A86-49126
Airplane landing behaviors controlled by man-pilots p 835 A86-49244
Turbulent transonic flow for NACA 0012/RAE 2822 airfoils under Baldwin-Lomax model p 776 A86-49245
Failure detection in a flight control system by the modified sequential probability ratio test p 854 A86-49507
Navier-Stokes simulation of transonic flow over wing-fuselage combinations p 779 A86-49589
[AIAA PAPER 86-1831]

N

NETHERLANDS

Design of an integrated control system for flutter margin augmentation and gust load alleviation, tested on a dynamic windtunnel model p 824 A86-47490
[AIAA PAPER 86-2242]
Flight simulation of MLS interception procedures applicable to laterally segmented approach paths p 837 A86-47663
[AIAA PAPER 86-2073]
Engine condition monitoring at KLM Royal Dutch Airlines p 816 A86-48312
[ASME PAPER 86-GT-300]
Applications of computer-aided engineering to subsonic aircraft design in a university environment p 801 A86-48986
Flight simulation techniques with emphasis on the generation of high fidelity 6 DOF motion cues p 839 A86-49024
Fatigue fracture in landing gear steels p 803 A86-49115
Calculation of 2-D unsteady transonic full potential flow about oscillating airfoils by two complementary approaches p 778 A86-49586
[AIAA PAPER 86-1821]
Computations of separated subsonic and transonic flow about airfoils in unsteady motion p 782 A86-31541
[NLR-MP-84094-U]
Flight data recorders (FDR) and/or cockpit Voice Recorders (CVR) in the Lockheed Orion P-3C Update 2 [ETN-86-97395] p 811 A86-31581
Preliminary design of an automated Air Traffic Control (ATC) radar evaluation system p 789 A86-32419
[NPL-VG-84-009-L]
The generation of equal probability design load conditions, using Power Spectral Density (PSD) techniques p 809 A86-32430
[NLR-TR-85014-U]
Flight test instrumentation used in the Fokker F27 and F28 development and certification flight program p 811 A86-32431
[NLR-MP-84023-U]
TURBISTAN: A standard load sequence for aircraft engine disks p 820 A86-32436
[NLR-MP-85033-U]
Recent developments in propulsion aerodynamics p 820 A86-32437
[NLR-MP-85031-U]
Cost reductions from introduction of new life philosophies for aircraft engine discs p 820 A86-32438
[NLR-MP-85076-U]
Review of aeronautical fatigue investigations in the Netherlands during the period March 1983 - February 1985 p 851 A86-32779
[NLR-MP-85025-U]
Short cracks in aerospace structures p 851 A86-32781
[NLR-MP-85054-U]

Simulation and optimization techniques in computer aided design p 854 A86-33053
[NLR-MP-85022-U]
An infrastructure for information processing for computer aided design p 854 A86-33054
[NLR-MP-85038-U]
On the way to extended noise reductions in propeller aircraft p 857 A86-33126
[B8573697]

P

POLAND

Solid-beam model of a deformable aircraft for natural-vibration studies p 804 A86-49444

R

ROMANIA (RUMANIA)

On the optimization of flutter characteristics of laminated anisotropic cylindrical shells p 848 A86-49082

S

SOUTH AFRICA, REPUBLIC OF

A comparison of pod and tail mounted ramjets p 818 A86-49112

SPAIN

Cancellation zone in supersonic lifting wing theory p 780 A86-49824

SWEDEN

Transonic computations about complex configurations using coupled inner and outer flow equations p 771 A86-49008
Disordered vortex flow computed around a cranked delta wing at subsonic speed and high incidence p 772 A86-49027
Failure analysis of aircraft windshields subjected to bird impact p 802 A86-49055
Numerical design parameter study for slotted walls in transonic wind tunnels p 839 A86-49059
Method of analysing data on a swept wing aircraft in flight p 775 A86-49103
The control and use of residual stresses in aircraft structural parts p 849 A86-49114
Measurements of landing gear loads of a commuter airliner p 803 A86-49119
Calculation of static elastic effects on a modern high performance fighter aircraft p 777 A86-49577
[AIAA PAPER 86-1771]
A comparison between acoustic mode measurements and acoustic finite element analysis performed for SAA8 SF 340 p 856 A86-33125
[FFA-TN-1986-22]

SWITZERLAND

Planning for minimum overhaul time p 760 A86-47616
A general computational method for simulation and prediction of transient behavior of gas turbines p 815 A86-48230
[ASME PAPER 86-GT-180]
Quality assurance in the reconditioning of gas turbine and compressor blading components p 847 A86-48311
[ASME PAPER 86-GT-299]
Can Europe meet the challenge of LHX? p 787 A86-48370
Airports build for future traffic amid new security concern p 838 A86-48371
Secondary radar leads - Monopulse points the way p 787 A86-48372

U

U.S.S.R.

Optimization of onboard systems of data acquisition and processing p 810 A86-48531
The adjustment of a turbojet engine compressor by the rotation of the guide vanes with the objective of reducing fuel consumption during throttle operation p 816 A86-48757
Calculation of the loading of the airframe in flight due to multidimensional turbulence p 799 A86-48759
Methods for minimizing Boolean functions in the automation of experimental studies of the survivability of aircraft structures p 853 A86-48760
A study of the relationship between nonlinear changes in the lifting force and the vortex structure of flow around a low aspect ratio wing at large angles of attack p 767 A86-48762
Selecting the shape of the middle surface of the pylons and the mounting angles of single nacelles under the wing of subsonic aircraft p 800 A86-48767

Hypothesis of two-dimensional cross sections for a wing of finite span at supersonic velocities p 767 A86-48769

Self-oscillatory regimes of aircraft motion during spin-roll coupling p 832 A86-48775
Method for determining the efficiency of utilization of the material in a thin-wall aircraft structure according to the strength conditions p 847 A86-48776
Effect of cantilever sweep on the aerodynamic characteristics of a wing with a projection in separated flow p 768 A86-48779
Effect of the nonequilibrium character of the flow around a blunt plate with a bend on its aerodynamic characteristics p 788 A86-48783
Determination of the required number of channels for controlling aircraft wing loading for several cases of calculation p 768 A86-48787
Divergence of an anisotropic sweptforward wing p 768 A86-48788
The effect of the aspect ratio of the cylindrical section on the fuselage drag at transonic flight velocities p 768 A86-48801
The drag of a pair of bodies at supersonic flight velocities p 768 A86-48802
Oscillation equations for a helicopter rotor blade p 800 A86-48805
Method for calculating pressure distribution on the surfaces of wings with slit mechanization p 768 A86-48806
Method for calculating subsonic ideal-gas flow past an aircraft p 768 A86-48807
Method for the visualization of subsonic gas flows p 769 A86-48808
Acceleration of the convergence of methods for calculating two- and three-dimensional transonic flow past bodies in an unbounded stream p 769 A86-48809
Determination of off-design flowrates according to the position of branching points on an under-the-wing (over-the-wing) air intake p 769 A86-48812
Similarity criteria for a circulation control airfoil p 769 A86-48815
Determination of the aerodynamic characteristics of separated flow past a wing with allowance for slight unsteadiness induced by changes in angle of attack p 769 A86-48816
Transonic flow past the root section of a wing with sweepback and sweepforward p 769 A86-48817
Nonuniqueness of laminar separated flow around an airfoil at angle of attack in the Kirchhoff scheme p 769 A86-48822
Experimental investigation of a boundary layer on a schematic aircraft model p 769 A86-48824
Determination of the shape of a jet issuing from a cylinder of finite length around which a supersonic stream flows at small angle of attack p 770 A86-48825
A certain type of self-oscillation of aircraft landing-gear wheels p 800 A86-48829
Method for the calculation and design of fuselage flaps made of composite materials p 847 A86-48830
The use of the magnetic aerohydrodynamic analogy method to simulate three-dimensional flow past aircraft, taking powerplant operation into account p 770 A86-48833
Wave drag of a supersonic air intake at high subsonic velocities p 770 A86-48834
Symmetric and nonsymmetric separated flow past a low aspect ratio wing with a fuselage p 770 A86-48838
Flow of an ideal fluid in the core of a vortex sheet p 770 A86-48839
An analysis of flow of a nonviscous incompressible fluid past a wing of finite thickness in the presence of a screen p 770 A86-48841
A study of the characteristics of separated flow past wings and lifting systems p 770 A86-48842
The effect of equilibrium air properties and Mach number on the aerodynamic characteristics of a flight vehicle p 770 A86-48843
Determination of the statistical characteristics of aircraft motion during an automatic approach p 832 A86-48844
Determination of the required stiffness characteristics for a large aspect ratio wing from the conditions of static strength and aileron efficiency p 800 A86-48845
Shape optimization of aircraft structural elements with stress raisers p 848 A86-48846
The effect of a kinetic air model on the aerodynamic characteristics of airfoils with flaps p 771 A86-48849
Modeling the elasticity of a wing structure p 800 A86-48850
Details of analysis of airplane structure acoustic loading in flight testing p 804 A86-49129
The problem of flow past a plane delta wing with power-law injection at its surface p 776 A86-49174
Prediction of the life of stressed structures - A comprehensive study of the aircraft landing gear p 804 A86-49288

- The effect of a fault on the stiffness and the natural frequency of a plate in bending p 850 A86-49918
 The effect of the monoethers of dicarboxylic acids on the antiwear properties of jet fuels p 843 A86-49963
 An analysis of the quality of aviation lubricants by liquid and gas-liquid chromatography p 844 A86-49964

UNITED ARAB REPUBLIC

- A stochastic decentralized flight control system [AIAA PAPER 86-1994] p 821 A86-47416

UNITED KINGDOM

- The observation of high frequency B(dot) and D(dot) transients excited on a fuselage by an impulse generator p 790 A86-47306
 The energy requirements of an aircraft triggered discharge p 844 A86-47315
 Aspects of lightning protection schemes for radomes p 792 A86-47338
 A parameter insensitive technique for aircraft sensor fault analysis using eigenstructure assignment and analytical redundancy [AIAA PAPER 86-2029] p 809 A86-47420
 Working with today's BITE - One airline's experience p 759 A86-47608
 Ageing aircraft as seen by an authority p 783 A86-47611
 Modern crack detection methods - The use of low frequency eddy currents to assist structural integrity auditing p 845 A86-47613
 Recursive real-time identification of step-response matrices of high-performance aircraft for adaptive digital flight control [AIAA PAPER 86-2017] p 826 A86-47652
 Some aspects of supersonic flow over a cavity cascade [AIAA PAPER 86-2025] p 764 A86-47659
 Acceleration performance of helicopter engines [ASME PAPER 86-GT-121] p 814 A86-48180
 The performance of a reverse flow combustor using JP 10 fuel [ASME PAPER 86-GT-146] p 814 A86-48202
 Conical grid plate flame stabilizers - Stability and emissions for liquid fuels [ASME PAPER 86-GT-156] p 842 A86-48210
 The aerodynamic potential of anti-sound p 855 A86-48977
 Future trends in propulsion p 816 A86-48979
 Automated structural optimisation at Warton p 854 A86-48987
 The British Aerospace Experimental Aircraft Programme and the role of system development cockpits p 801 A86-48996
 The design and construction of a post buckled carbon fibre wing box structure p 848 A86-49001
 Active flutter suppression p 832 A86-49004
 Active control technology for civil transport p 832 A86-49005
 Designing a load alleviation system for a modern civil aircraft p 832 A86-49006
 The high lift development of the A320 aircraft p 772 A86-49012
 An experimental study of turbulent wake/boundary layer mixing flows p 772 A86-49014
 Materials in aerospace - Can the emerging thermoplastics meet the challenge? p 843 A86-49020
 Advanced polymer composites for high temperature applications p 843 A86-49021
 Handling qualities for unstable combat aircraft p 833 A86-49025
 Boundary layer calculation and viscous-inviscid coupling p 773 A86-49031
 Wake/boundary-layer interactions in two and three dimensions p 773 A86-49032
 On the duration of low speed dynamic stall p 773 A86-49033
 Managing airworthiness p 785 A86-49035
 Certification of advanced experimental aircraft p 785 A86-49036
 Plastic or metal - The judgement factors p 762 A86-49037
 The estimation of the stability and control characteristics of a canard configured combat aircraft having a forward swept wing p 834 A86-49056
 Advances in turbine technology p 817 A86-49079
 The role of flow field computation in improving turbomachinery p 775 A86-49080
 The airline engineering role in the management of safety p 762 A86-49084
 Case studies of the effects on non-linearities on the accuracy of gas turbine control p 817 A86-49090
 Potential application of advanced propulsion systems to civil aircraft p 802 A86-49093
 Active noise control p 803 A86-49101
 The development of a fibre optic data bus for helicopters p 811 A86-49131
 Harrier the viffer p 763 A86-49681

- Truncated Taylor series solutions to a generalized Burgers' equation p 856 A86-49716
 Dynamic analysis: Correlation of theory with experiment [RP661] p 851 N86-31917
 An improved optical viewing system for a flight simulator [MS-8025] p 840 N86-32448

Y

YUGOSLAVIA

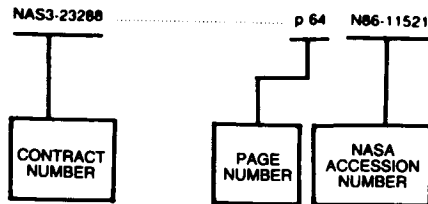
- Various approaches in solving stability problems for symmetric angle-ply laminates under combined loading p 848 A86-49040

CONTRACT NUMBER INDEX

AERONAUTICAL ENGINEERING / A Continuing Bibliography (Supplement 208)

January 1987

Typical Contract Number Index Listing



Listings in this index are arranged alphabetically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the AIAA accession numbers appearing first. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

AF-AFOSR-ISSA-85-00051	p 823	A86-47475
AF-AFOSR-81-0037	p 853	A86-47479
AF-AFOSR-83-0083	p 780	A86-49801
AF-AFOSR-84-0371	p 844	A86-47315
AF-AFOSR-85-0208	p 823	A86-47485
DAAG29-82-K-0029	p 826	A86-47652
DAAG29-84-K-0048	p 765	A86-48188
DAEA18-84-C-0127	p 822	A86-47442
DE-AC04-78DP-00789	p 789	N86-31554
DRET-79-436	p 808	N86-31576
DRET-83-308	p 798	A86-48857
DRET-83-34-355	p 783	A86-47299
DRET-84-1214	p 851	N86-32784
DRET-84-34-001	p 851	N86-32785
DTFA03-84-C-0004	p 783	A86-47299
F09603-83-C-1680	p 787	N86-32416
F33615-78-C-2063	p 809	A86-47325
	p 807	N86-31570
	p 807	N86-31571
	p 807	N86-31572
	p 807	N86-31573
F33615-79-C-2087	p 813	A86-48156
F33615-82-C-0520	p 825	A86-47495
F33615-82-K-3610	p 759	A86-47444
F33615-83-C-3603	p 792	A86-47485
	p 827	A86-47665
	p 831	A86-47706
F33615-84-C-3604	p 824	A86-47483
F33615-85-C-3009	p 841	A86-47902
F33615-85-C-3619	p 830	A86-47695
F49620-83-C-0048	p 780	A86-49807
F49620-83-K-0009	p 764	A86-47698
F49620-84-C-0065	p 764	A86-47700
MIPR-FY-1456-85-00032	p 779	A86-49593
MOD-A81A/2093	p 792	A86-47338
MOD-2028/0153/XR/STR	p 848	A86-49001
MOD-2101/063/XR/ST	p 832	A86-49004
MOD-85A/431	p 840	N86-32448
MODA268/10	p 851	N86-31917
NAG1-217	p 825	A86-47494
NAG1-254	p 828	A86-47866
	p 835	N86-31590
NAG1-344	p 775	A86-49104
	p 776	A86-49122
NAG1-345	p 836	N86-32440
NAG1-390	p 805	A86-49808
NAG1-452	p 781	N86-31531
NAG1-516	p 822	A86-47425
	p 834	A86-49071
NAG1-591	p 774	A86-49045
NAG1-648	p 774	A86-49045

NAG3-200	p 813	A86-48163
NAG3-308	p 846	A86-48271
NAS1-16535	p 780	A86-49804
NAS1-17411	p 821	A86-47422
NAS1-17556	p 821	A86-47419
NAS1-17686	p 796	A86-47800
NAS2-11851	p 772	A86-49009
NAS2-11978	p 792	A86-47704
NAS3-23051	p 781	N86-31536
NCC2-106	p 793	A86-47705
NGL-31-001-252	p 834	A86-49070
NIVR-1994	p 782	N86-31541
NIVR-1995	p 809	N86-32430
NSF ATM-80-20415	p 783	A86-47332
NSF ATM-82-09684	p 783	A86-47332
NSF DMS-84-13129	p 825	A86-47494
NSF ECS-84-15581	p 823	A86-47475
	p 853	A86-47479
NSF MEA-81-8565	p 772	A86-49011
NSG-3036	p 856	A86-49806
N00019-83-G-0412	p 787	A86-47517
N00140-80-C-2269	p 842	A86-48159
N00140-83-C-9119	p 842	A86-48123
N00167-83-C-0114	p 777	A86-49573
N62269-83-C-0220	p 828	A86-47674
RB-RLD-1984-3.1	p 789	N86-32419
SERC-GR/B/82812	p 842	A86-48210
SERC-GR/D/25820	p 842	A86-48210
STPA-83-95-019	p 809	N86-32429
STPA-84-95-005	p 779	A86-49582
505-33-43	p 806	N86-31568
505-43-13-01	p 781	N86-31532
505-43-43-01	p 781	N86-31531
505-60-00	p 782	N86-32392
505-60-0	p 781	N86-31535
505-60	p 850	N86-31827
505-61-41-02	p 836	N86-32440
505-66-01-01	p 835	N86-31590
505-66-41-05	p 835	N86-31591
505-68-11	p 786	N86-31548
	p 806	N86-31562
505-69-41	p 819	N86-31586
532-06-11	p 789	N86-31551
535-03-01	p 781	N86-31536
535-05-01	p 819	N86-31582
	p 819	N86-31587

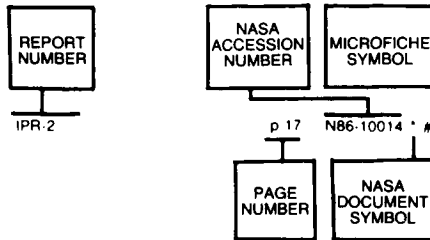
CONTRACT

REPORT NUMBER INDEX

AERONAUTICAL ENGINEERING / A Continuing Bibliography (Supplement 208)

January 1987

Typical Report Number Index Listing



Listings in this index are arranged alphabetically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A-85359 p 781 N86-31535 * #
A-86165 p 763 N86-31527 * #
A-86199 p 850 N86-31827 * #
A-86222 p 782 N86-32392 * #

AAAF PAPER NT 85-01 p 766 A86-48452 #
AAAF PAPER NT 85-03 p 766 A86-48454 #
AAAF PAPER NT 85-04 p 766 A86-48455 #
AAAF PAPER NT 85-06 p 838 A86-48457 #
AAAF PAPER NT 85-08 p 766 A86-48458 #
AAAF PAPER NT 85-16 p 767 A86-48465 #
AAAF PAPER NT 85-18 p 797 A86-48467 #
AAAF PAPER NT 85-19 p 797 A86-48468 #

AD-A166298 p 763 N86-31528 #
AD-A167113 p 807 N86-31569 #
AD-A167149 p 763 N86-31529 #
AD-A167356 p 807 N86-31570 #
AD-A167400 p 856 N86-32249 #
AD-A167443 p 807 N86-31571 #
AD-A167444 p 807 N86-31572 #
AD-A167445 p 807 N86-31573 #
AD-A167575 p 808 N86-31574 #
AD-A167717 p 781 N86-31539 #
AD-A167719 p 808 N86-31575 #
AD-A167727 p 838 N86-31592 #
AD-A167774 p 786 N86-31549 #
AD-A167780 p 789 N86-31554 #
AD-A167811 p 840 N86-31598 #
AD-A167867 p 789 N86-31555 #
AD-A167977 p 840 N86-31602 #
AD-A167988 p 789 N86-31556 #
AD-A168555 p 809 N86-32428 #
AD-A168846 p 787 N86-32416 #

AD-D012240 p 789 N86-31552 #
AD-D012276 p 850 N86-31860 #
AD-D012295 p 851 N86-32746 #

AFIT/CI/NR-86-53T p 807 N86-31569 #
AFIT/CI/NR-86-56T p 836 N86-31592 #

AFIT/GOR/OS/85D-3 p 763 N86-31529 #

AFWAL-TR-85-2060-VOL-1 p 807 N86-31571 #
AFWAL-TR-85-2060-VOL-2-PT-2 p 807 N86-31572 #
AFWAL-TR-85-2060-VOL-2-PT-1 p 807 N86-31570 #
AFWAL-TR-85-2060-VOL-3-PT-2 p 807 N86-31573 #

AGARD-AR-226 p 782 N86-32408 #

AIAA PAPER 80-2018 p 826 A86-47653 * #
AIAA PAPER 86-0467 p 856 A86-49566 * #
AIAA PAPER 86-0941 p 849 A86-49572 #
AIAA PAPER 86-0997 p 777 A86-49573 #

AIAA PAPER 86-1134 p 857 A86-49571 #
AIAA PAPER 86-1452 p 818 A86-49611 * #
AIAA PAPER 86-1611 p 818 A86-49614 * #
AIAA PAPER 86-1768 p 777 A86-49576 #
AIAA PAPER 86-1771 p 777 A86-49577 #
AIAA PAPER 86-1774 p 777 A86-49578 #
AIAA PAPER 86-1775 p 777 A86-49579 #
AIAA PAPER 86-1780 p 778 A86-49580 * #
AIAA PAPER 86-1794 p 778 A86-49581 #
AIAA PAPER 86-1798 p 778 A86-49582 #
AIAA PAPER 86-1807 p 778 A86-49584 #
AIAA PAPER 86-1809 p 778 A86-49585 #
AIAA PAPER 86-1821 p 778 A86-49586 #
AIAA PAPER 86-1829 p 779 A86-49588 #
AIAA PAPER 86-1831 p 779 A86-49589 #
AIAA PAPER 86-1832 p 779 A86-49590 #
AIAA PAPER 86-1834 p 779 A86-49591 #
AIAA PAPER 86-1837 p 779 A86-49592 #
AIAA PAPER 86-1838 p 779 A86-49593 #
AIAA PAPER 86-1858 p 856 A86-49575 #
AIAA PAPER 86-1893 p 780 A86-49625 * #
AIAA PAPER 86-1994 p 821 A86-47416 #
AIAA PAPER 86-1995 p 852 A86-47417 #
AIAA PAPER 86-1996 p 852 A86-47418 #
AIAA PAPER 86-2000 p 841 A86-47902 #
AIAA PAPER 86-2017 p 826 A86-47652 #
AIAA PAPER 86-2019 p 827 A86-47654 #
AIAA PAPER 86-2020 p 827 A86-47655 #
AIAA PAPER 86-2025 p 764 A86-47659 #
AIAA PAPER 86-2026 p 827 A86-47660 #
AIAA PAPER 86-2027 p 827 A86-47661 #
AIAA PAPER 86-2028 p 821 A86-47419 #
AIAA PAPER 86-2029 p 809 A86-47420 #
AIAA PAPER 86-2030 p 810 A86-47511 #
AIAA PAPER 86-2031 p 821 A86-47421 #
AIAA PAPER 86-2032 p 821 A86-47422 #
AIAA PAPER 86-2035 p 822 A86-47424 #
AIAA PAPER 86-2036 p 822 A86-47425 #
AIAA PAPER 86-2037 p 797 A86-48576 #
AIAA PAPER 86-2072 p 837 A86-47662 #
AIAA PAPER 86-2073 p 837 A86-47663 #
AIAA PAPER 86-2074 p 838 A86-47664 #
AIAA PAPER 86-2075 p 831 A86-47706 #
AIAA PAPER 86-2076 p 827 A86-47665 #
AIAA PAPER 86-2077 p 828 A86-47666 #
AIAA PAPER 86-2084 p 822 A86-47437 #
AIAA PAPER 86-2085 p 853 A86-47505 #
AIAA PAPER 86-2088 p 852 A86-47439 #
AIAA PAPER 86-2092 p 822 A86-47442 #
AIAA PAPER 86-2093 p 853 A86-48577 #
AIAA PAPER 86-2095 p 759 A86-47444 #
AIAA PAPER 86-2126 p 828 A86-47672 #
AIAA PAPER 86-2128 p 828 A86-47674 #
AIAA PAPER 86-2129 p 828 A86-47675 #
AIAA PAPER 86-2130 p 828 A86-47676 #
AIAA PAPER 86-2131 p 828 A86-47677 #
AIAA PAPER 86-2134 p 841 A86-47679 #
AIAA PAPER 86-2143 p 826 A86-47516 #
AIAA PAPER 86-2144 p 822 A86-47455 #
AIAA PAPER 86-2146 p 787 A86-47517 #
AIAA PAPER 86-2147 p 823 A86-47456 #
AIAA PAPER 86-2148 p 810 A86-47457 #
AIAA PAPER 86-2157 p 823 A86-47464 #
AIAA PAPER 86-2158 p 823 A86-47465 #
AIAA PAPER 86-2160 p 852 A86-47466 #
AIAA PAPER 86-2180 p 829 A86-47683 #
AIAA PAPER 86-2195 p 823 A86-47475 #
AIAA PAPER 86-2196 p 852 A86-47476 #
AIAA PAPER 86-2197 p 853 A86-47477 #
AIAA PAPER 86-2199 p 853 A86-47479 #
AIAA PAPER 86-2201 p 823 A86-47481 #
AIAA PAPER 86-2202 p 823 A86-47482 #
AIAA PAPER 86-2203 p 824 A86-47483 #
AIAA PAPER 86-2204 p 853 A86-47484 #
AIAA PAPER 86-2205 p 787 A86-47519 #
AIAA PAPER 86-2206 p 792 A86-47485 #
AIAA PAPER 86-2226 p 829 A86-47689 #
AIAA PAPER 86-2227 p 829 A86-47690 #
AIAA PAPER 86-2229 p 831 A86-47708 #
AIAA PAPER 86-2230 p 764 A86-47691 #
AIAA PAPER 86-2231 p 829 A86-47692 #
AIAA PAPER 86-2232 p 829 A86-47693 #
AIAA PAPER 86-2234 p 829 A86-47694 #

AIAA PAPER 86-2236 p 824 A86-47488 #
AIAA PAPER 86-2237 p 824 A86-47489 #
AIAA PAPER 86-2242 p 824 A86-47490 #
AIAA PAPER 86-2243 p 824 A86-47491 #
AIAA PAPER 86-2244 p 824 A86-47492 #
AIAA PAPER 86-2246 p 825 A86-47493 #
AIAA PAPER 86-2247 p 825 A86-47494 #
AIAA PAPER 86-2248 p 825 A86-47495 #
AIAA PAPER 86-2249 p 826 A86-47523 #
AIAA PAPER 86-2250 p 825 A86-47496 #
AIAA PAPER 86-2251 p 825 A86-47497 #
AIAA PAPER 86-2253 p 826 A86-47509 #
AIAA PAPER 86-2277 p 830 A86-47695 #
AIAA PAPER 86-2278 p 830 A86-47696 #
AIAA PAPER 86-2279 p 830 A86-47697 #
AIAA PAPER 86-2280 p 764 A86-47698 #
AIAA PAPER 86-2281 p 764 A86-47699 #
AIAA PAPER 86-2282 p 764 A86-47700 #
AIAA PAPER 86-2283 p 830 A86-47701 #
AIAA PAPER 86-2284 p 830 A86-47702 #
AIAA PAPER 86-2285 p 787 A86-47703 #
AIAA PAPER 86-2286 p 792 A86-47704 #
AIAA PAPER 86-2287 p 793 A86-47705 #
AIAA PAPER 86-2288 p 831 A86-47709 #
AIAA PAPER 86-2289 p 821 A86-47402 #

AIAA-86-1542 p 819 N86-31587 * #

AR-004-467 p 808 N86-32425 #
AR-86-1 p 781 N86-31531 * #

ARL-AERO-TM-379 p 808 N86-32425 #

ARL/SYS-TM-86 p 789 N86-31556 #

ASME PAPER 86-DE-6 p 818 A86-49620 #
ASME PAPER 86-GT-102 p 814 A86-48165 #
ASME PAPER 86-GT-103 p 814 A86-48166 #
ASME PAPER 86-GT-108 p 765 A86-48170 #
ASME PAPER 86-GT-110 p 765 A86-48172 #
ASME PAPER 86-GT-111 p 765 A86-48173 #
ASME PAPER 86-GT-117 p 765 A86-48176 #
ASME PAPER 86-GT-121 p 814 A86-48180 #
ASME PAPER 86-GT-125 p 797 A86-48184 #
ASME PAPER 86-GT-130 p 765 A86-48188 #
ASME PAPER 86-GT-146 p 814 A86-48202 #
ASME PAPER 86-GT-156 p 842 A86-48210 #
ASME PAPER 86-GT-157 p 814 A86-48211 #
ASME PAPER 86-GT-163 p 843 A86-48216 #
ASME PAPER 86-GT-168 p 814 A86-48220 #
ASME PAPER 86-GT-172 p 815 A86-48224 #
ASME PAPER 86-GT-174 p 815 A86-48225 #
ASME PAPER 86-GT-180 p 815 A86-48230 #
ASME PAPER 86-GT-181 p 815 A86-48231 #
ASME PAPER 86-GT-189 p 766 A86-48239 #
ASME PAPER 86-GT-191 p 815 A86-48241 #
ASME PAPER 86-GT-191 p 812 A86-48101 #
ASME PAPER 86-GT-212 p 815 A86-48252 #
ASME PAPER 86-GT-228 p 766 A86-48262 #
ASME PAPER 86-GT-243 p 846 A86-48271 #
ASME PAPER 86-GT-243 p 812 A86-48116 #
ASME PAPER 86-GT-252 p 816 A86-48278 #
ASME PAPER 86-GT-255 p 846 A86-48281 #
ASME PAPER 86-GT-262 p 843 A86-48285 #
ASME PAPER 86-GT-266 p 847 A86-48288 #
ASME PAPER 86-GT-277 p 816 A86-48296 #
ASME PAPER 86-GT-285 p 816 A86-48302 #
ASME PAPER 86-GT-28 p 812 A86-48119 #
ASME PAPER 86-GT-295 p 797 A86-48308 #
ASME PAPER 86-GT-299 p 847 A86-48311 #
ASME PAPER 86-GT-2 p 812 A86-48102 #
ASME PAPER 86-GT-300 p 816 A86-48312 #
ASME PAPER 86-GT-36 p 842 A86-48123 #
ASME PAPER 86-GT-37 p 812 A86-48124 #
ASME PAPER 86-GT-38 p 812 A86-48125 #
ASME PAPER 86-GT-3 p 812 A86-48103 #
ASME PAPER 86-GT-46 p 846 A86-48130 #
ASME PAPER 86-GT-52 p 813 A86-48132 #
ASME PAPER 86-GT-56 p 765 A86-48134 #
ASME PAPER 86-GT-70 p 813 A86-48141 #
ASME PAPER 86-GT-76 p 813 A86-48144 #
ASME PAPER 86-GT-80 p 813 A86-48148 #
ASME PAPER 86-GT-90 p 813 A86-48156 #

REPORT

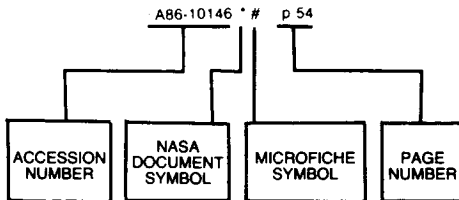
ASME PAPER 86-GT-94	p 842	A86-48159	#	ETN-86-98032	p 851	N86-32781	#	NLR-TR-85014-U	p 809	N86-32430	#
ASME PAPER 86-GT-98	p 813	A86-48163	* #	ETN-86-98036	p 809	N86-32430	#	NOTE-427.021/86	p 806	N86-31587	#
ASME PAPER 86-GT-99	p 813	A86-48164	* #	ETN-86-98075	p 837	N86-32445	#	NPL-VG-84-009-L	p 789	N86-32419	#
B-222851	p 787	N86-32418	#	FAA-AC/25.994-1	p 806	N86-31564	#	NUSC-TM-861043	p 856	N86-32249	#
BMFT-FB-W-85-022	p 808	N86-31577	#	FAA-EE-86-02	p 840	N86-31602	#	ONERA-RT-12/1677-RY-090-R	p 809	N86-32429	#
BMFT-FB-W-85-029	p 840	N86-31604	#	FAA/PM-86/35	p 811	N86-31580	#	ONERA-RT-19/3463-AYP	p 841	N86-32451	#
BMFT-FB-W-85-031	p 820	N86-31589	#	FFA-TN-1986-22	p 856	N86-33125	#	ONERA, TP NO. 1986-100	p 818	A86-49125	#
BR98992	p 840	N86-32448	#	FTD-ID(RS)T-0844-85	p 763	N86-31528	#	ONERA, TP NO. 1986-101	p 776	A86-49106	#
BR97157	p 851	N86-31917	#	GAO/RCED-86-105FS	p 787	N86-32418	#	ONERA, TP NO. 1986-102	p 843	A86-49077	#
B8573697	p 857	N86-33126	#	HSE-9333	p 781	N86-31536	* #	ONERA, TP NO. 1986-104	p 839	A86-49075	#
B8661087	p 811	N86-32431	#	ISL-CO-219/85	p 851	N86-31872	#	ONERA, TP NO. 1986-105	p 800	A86-48978	#
B8664045	p 782	N86-31541	#	ISSN-0170-1339	p 808	N86-31577	#	ONERA, TP NO. 1986-122	p 773	A86-49042	#
B8664046	p 854	N86-33054	#	ISSN-0170-1339	p 820	N86-31589	#	PB86-197506	p 787	N86-32418	#
B8664738	p 851	N86-32779	#	ISSN-0170-1339	p 840	N86-31604	#	P86-10182	p 806	N86-31563	* #
B8664743	p 820	N86-32437	#	ISSN-0171-1342	p 837	N86-32446	#	REPT-2959-01-1-3759	p 789	N86-31554	#
B8665116	p 820	N86-32438	#	KU-FRL-6132-2	p 836	N86-32440	* #	REPT-4950/FTR-86-1	p 786	N86-31549	#
B8665117	p 820	N86-32436	#	L-15919	p 781	N86-31532	* #	REPT-85349	p 789	N86-31551	* #
B8665120	p 854	N86-33053	#	LR-30777-REV	p 787	N86-32416	#	RP661	p 851	N86-31917	#
B8665499	p 851	N86-32781	#	MBB-UD-452-85-OE	p 805	A86-50253	#	SAND-85-2236	p 808	N86-31576	#
B8665725	p 809	N86-32430	#	MBB-UD-454-85-OE	p 808	A86-50256	#	SNIAS-436.021/85	p 851	N86-32784	#
CONF-860519-4	p 808	N86-31576	#	MBB-UD-456-85-OE	p 805	A86-50255	#	SNIAS-861-111-114	p 806	N86-31565	#
DE86-008462	p 808	N86-31576	#	MBB-UD-458-85-OE	p 805	A86-49509	#	SNIAS-861-210-108	p 836	N86-32444	#
DFVLR-FB-84-48	p 837	N86-32445	#	MBB-UD-462-85-OE	p 850	A86-50254	#	US-PATENT-APPL-SN-435515	p 850	N86-31860	#
DFVLR-FB-85-01-PT-2	p 782	N86-31542	#	MS-8025	p 840	N86-32448	#	US-PATENT-APPL-SN-565481	p 840	N86-32447	* #
DFVLR-FB-85-05	p 782	N86-31543	#	NAL-PD-SE-8614	p 854	N86-33042	#	US-PATENT-APPL-SN-823872	p 789	N86-31552	#
DFVLR-FB-85-08	p 789	N86-31558	#	NAL-TRM-SE-8603	p 782	N86-32393	#	US-PATENT-APPL-SN-832114	p 851	N86-32746	#
DFVLR-FB-85-24	p 836	N86-31593	#	NAS 1.15:86779	p 789	N86-31551	* #	US-PATENT-CLASS-356-73	p 840	N86-32447	* #
DFVLR-FB-85-27	p 808	N86-31578	#	NAS 1.15:86783	p 781	N86-31535	* #	US-PATENT-CLASS-364-481	p 850	N86-31860	#
DFVLR-FB-86-08	p 837	N86-32446	#	NAS 1.15:87191	p 806	N86-31562	* #	US-PATENT-4,571,689	p 850	N86-31860	#
DFVLR-MITT-85-08	p 808	N86-31579	#	NAS 1.15:87304	p 819	N86-31582	* #	US-PATENT-4,605,303	p 840	N86-32447	* #
DOT/FAA/CT-TN86/10	p 789	N86-31555	#	NAS 1.15:87316	p 820	N86-31588	* #	USAAVSCOM-TR-86-C-23	p 819	N86-31587	* #
DOT/FAA/CT-85/10-REV	p 787	N86-32416	#	NAS 1.15:87722	p 781	N86-31532	* #				
DYN/83/10	p 851	N86-31917	#	NAS 1.15:87766	p 806	N86-31568	* #				
D180-28860-1-VOL-1	p 807	N86-31571	#	NAS 1.15:88237	p 850	N86-31827	* #				
D180-28861-1	p 807	N86-31570	#	NAS 1.15:88240	p 763	N86-31527	* #				
D180-28862-VOL-2-PT-2	p 807	N86-31572	#	NAS 1.15:88248-PT-2	p 782	N86-32392	* #				
E-2847	p 806	N86-31562	* #	NAS 1.15:88791	p 786	N86-31548	* #				
E-3016	p 819	N86-31582	* #	NAS 1.15:88796	p 819	N86-31587	* #				
E-3047	p 820	N86-31588	* #	NAS 1.15:88808	p 819	N86-31586	* #				
E-3121	p 786	N86-31548	* #	NAS 1.15:88817	p 819	N86-31585	* #				
E-3131	p 819	N86-31587	* #	NAS 1.15:89001	p 835	N86-31581	* #				
E-3156	p 819	N86-31586	* #	NAS 1.26:174789	p 781	N86-31536	* #				
E-3177	p 819	N86-31585	* #	NAS 1.26:178163	p 781	N86-31531	* #				
ESA-TT-916-PT-2	p 782	N86-31542	#	NAS 1.26:178164	p 835	N86-31590	* #				
ESA-TT-919	p 837	N86-32445	#	NAS 1.26:4014	p 836	N86-32440	* #				
ESA-TT-923	p 782	N86-31543	#	NASA-CASE-ARC-11504-1	p 840	N86-32447	* #				
ESA-TT-928	p 789	N86-31558	#	NASA-CR-174789	p 781	N86-31536	* #				
ESA-TT-936	p 808	N86-31579	#	NASA-CR-178163	p 781	N86-31531	* #				
ESA-TT-948	p 836	N86-31593	#	NASA-CR-178164	p 835	N86-31590	* #				
ESA-TT-951	p 808	N86-31578	#	NASA-CR-4014	p 836	N86-32440	* #				
ETN-86-96555	p 840	N86-32448	#	NASA-TM-86779	p 789	N86-31551	* #				
ETN-86-97234	p 856	N86-33125	#	NASA-TM-86783	p 781	N86-31535	* #				
ETN-86-97258	p 851	N86-31917	#	NASA-TM-87191	p 806	N86-31562	* #				
ETN-86-97395	p 811	N86-31581	#	NASA-TM-87304	p 819	N86-31582	* #				
ETN-86-97460	p 808	N86-31577	#	NASA-TM-87316	p 820	N86-31588	* #				
ETN-86-97471	p 840	N86-31604	#	NASA-TM-87722	p 781	N86-31532	* #				
ETN-86-97472	p 820	N86-31589	#	NASA-TM-87766	p 806	N86-31568	* #				
ETN-86-97502	p 857	N86-33126	#	NASA-TM-87816	p 850	N86-31827	* #				
ETN-86-97569	p 782	N86-31542	#	NASA-TM-87722	p 763	N86-31527	* #				
ETN-86-97571	p 782	N86-31543	#	NASA-TM-87766	p 782	N86-32392	* #				
ETN-86-97572	p 789	N86-31558	#	NASA-TM-88237	p 786	N86-31548	* #				
ETN-86-97581	p 836	N86-31593	#	NASA-TM-88240	p 819	N86-31587	* #				
ETN-86-97583	p 808	N86-31578	#	NASA-TM-88248-PT-2	p 782	N86-32392	* #				
ETN-86-97592	p 806	N86-31565	#	NASA-TM-88791	p 786	N86-31548	* #				
ETN-86-97593	p 836	N86-32444	#	NASA-TM-88796	p 819	N86-31587	* #				
ETN-86-97628	p 851	N86-31872	#	NASA-TM-88808	p 819	N86-31586	* #				
ETN-86-97641	p 809	N86-32429	#	NASA-TM-88817	p 819	N86-31585	* #				
ETN-86-97665	p 811	N86-32431	#	NASA-TM-89001	p 835	N86-31591	* #				
ETN-86-97666	p 782	N86-31541	#	NLR-MP-84023-U	p 811	N86-32431	#				
ETN-86-97670	p 854	N86-33053	#	NLR-MP-84094-U	p 782	N86-31541	#				
ETN-86-97672	p 851	N86-32779	#	NLR-MP-85022-U	p 854	N86-33053	#				
ETN-86-97675	p 820	N86-32437	#	NLR-MP-85025-U	p 851	N86-32779	#				
ETN-86-97676	p 820	N86-32436	#	NLR-MP-85031-U	p 820	N86-32437	#				
ETN-86-97677	p 854	N86-33054	#	NLR-MP-85033-U	p 820	N86-32436	#				
ETN-86-97685	p 820	N86-32438	#	NLR-MP-85038-U	p 854	N86-33054	#				
ETN-86-97779	p 789	N86-32419	#	NLR-MP-85054-U	p 851	N86-32781	#				
ETN-86-97800	p 808	N86-31579	#	NLR-MP-85076-U	p 820	N86-32438	#				
ETN-86-97818	p 837	N86-32446	#								
ETN-86-97873	p 841	N86-32451	#								
ETN-86-97877	p 851	N86-32784	#								
ETN-86-97878	p 851	N86-32785	#								

ACCESSION NUMBER INDEX

AERONAUTICAL ENGINEERING / A Continuing Bibliography (Supplement 208)

January 1987

Typical Accession Number Index Listing



Listings in this index are arranged alpha-numerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A86-47292	#	p 844	A86-47484	#	p 853
A86-47293	#	p 783	A86-47485	#	p 792
A86-47295	#	p 790	A86-47488	#	p 824
A86-47296	#	p 844	A86-47489	*	p 824
A86-47297	#	p 790	A86-47490	#	p 824
A86-47299	#	p 783	A86-47491	*	p 824
A86-47304	#	p 837	A86-47492	*	p 824
A86-47305	#	p 790	A86-47493	#	p 825
A86-47306	#	p 790	A86-47494	*	p 825
A86-47307	#	p 790	A86-47495	*	p 825
A86-47308	#	p 790	A86-47496	#	p 825
A86-47309	#	p 791	A86-47497	#	p 825
A86-47312	#	p 844	A86-47505	#	p 853
A86-47315	#	p 844	A86-47509	#	p 826
A86-47317	#	p 791	A86-47511	*	p 810
A86-47318	#	p 791	A86-47516	*	p 826
A86-47319	#	p 809	A86-47517	#	p 787
A86-47325	#	p 809	A86-47519	#	p 787
A86-47326	#	p 791	A86-47523	*	p 826
A86-47327	#	p 791	A86-47525	#	p 845
A86-47329	#	p 845	A86-47595	#	p 845
A86-47331	#	p 792	A86-47601	#	p 759
A86-47332	#	p 783	A86-47602	#	p 841
A86-47333	#	p 792	A86-47603	#	p 841
A86-47334	#	p 783	A86-47604	#	p 759
A86-47338	#	p 792	A86-47607	#	p 759
A86-47369	#	p 820	A86-47608	#	p 759
A86-47401	#	p 852	A86-47609	#	p 760
A86-47402	#	p 821	A86-47610	#	p 760
A86-47416	#	p 821	A86-47611	#	p 783
A86-47417	*	p 852	A86-47612	#	p 760
A86-47418	#	p 852	A86-47613	#	p 845
A86-47419	*	p 821	A86-47614	#	p 760
A86-47420	#	p 809	A86-47615	#	p 760
A86-47421	#	p 821	A86-47616	#	p 760
A86-47422	*	p 821	A86-47617	#	p 857
A86-47424	*	p 822	A86-47636	*	p 792
A86-47425	*	p 822	A86-47651	#	p 826
A86-47437	#	p 822	A86-47652	#	p 826
A86-47439	#	p 852	A86-47653	#	p 826
A86-47442	#	p 822	A86-47654	*	p 827
A86-47444	#	p 759	A86-47655	#	p 827
A86-47455	*	p 822	A86-47659	#	p 764
A86-47456	*	p 823	A86-47660	#	p 827
A86-47457	#	p 810	A86-47661	#	p 827
A86-47464	#	p 823	A86-47662	*	p 837
A86-47465	#	p 823	A86-47663	#	p 837
A86-47466	*	p 852	A86-47664	#	p 838
A86-47475	#	p 823	A86-47665	#	p 827
A86-47476	#	p 852	A86-47666	*	p 828
A86-47477	#	p 853	A86-47672	*	p 828
A86-47479	#	p 853	A86-47674	#	p 828
A86-47481	#	p 823	A86-47675	#	p 828
A86-47482	*	p 823	A86-47676	*	p 828
A86-47483	#	p 824	A86-47677	#	p 828

A86-47679	#	p 841	A86-48119	#	p 812	A86-48664	#	p 798
A86-47683	*	p 829	A86-48123	#	p 842	A86-48665	#	p 799
A86-47689	#	p 829	A86-48124	#	p 812	A86-48666	#	p 799
A86-47690	*	p 829	A86-48125	#	p 812	A86-48667	*	p 799
A86-47691	#	p 764	A86-48130	#	p 846	A86-48668	#	p 799
A86-47692	#	p 829	A86-48132	#	p 813	A86-48669	#	p 785
A86-47693	#	p 829	A86-48134	#	p 765	A86-48670	#	p 831
A86-47694	#	p 829	A86-48141	*	p 813	A86-48671	#	p 832
A86-47695	#	p 830	A86-48144	#	p 813	A86-48672	*	p 799
A86-47696	#	p 830	A86-48148	#	p 813	A86-48673	#	p 838
A86-47697	#	p 830	A86-48156	#	p 813	A86-48674	#	p 832
A86-47698	#	p 764	A86-48159	#	p 842	A86-48738	#	p 799
A86-47699	#	p 764	A86-48163	*	p 813	A86-48740	#	p 855
A86-47700	#	p 764	A86-48164	*	p 813	A86-48757	#	p 816
A86-47701	#	p 830	A86-48165	#	p 814	A86-48759	#	p 799
A86-47702	#	p 830	A86-48166	#	p 814	A86-48760	#	p 853
A86-47703	#	p 787	A86-48170	#	p 765	A86-48762	#	p 767
A86-47704	*	p 792	A86-48172	#	p 765	A86-48767	#	p 800
A86-47705	*	p 793	A86-48173	#	p 765	A86-48769	#	p 767
A86-47706	*	p 831	A86-48176	#	p 765	A86-48775	#	p 832
A86-47708	*	p 831	A86-48180	#	p 814	A86-48776	#	p 847
A86-47709	#	p 831	A86-48184	#	p 797	A86-48779	#	p 768
A86-47715	#	p 841	A86-48188	#	p 765	A86-48783	#	p 768
A86-47717	#	p 842	A86-48202	#	p 814	A86-48787	#	p 768
A86-47719	#	p 845	A86-48210	#	p 842	A86-48788	#	p 768
A86-47720	#	p 842	A86-48211	#	p 814	A86-48801	#	p 768
A86-47721	#	p 845	A86-48216	#	p 843	A86-48802	#	p 768
A86-47722	#	p 846	A86-48220	#	p 814	A86-48805	#	p 800
A86-47725	#	p 846	A86-48224	*	p 815	A86-48806	#	p 768
A86-47727	#	p 793	A86-48225	#	p 815	A86-48807	#	p 768
A86-47728	#	p 793	A86-48230	#	p 815	A86-48808	#	p 769
A86-47730	#	p 783	A86-48231	*	p 815	A86-48809	#	p 769
A86-47731	#	p 784	A86-48239	#	p 766	A86-48812	#	p 769
A86-47733	#	p 793	A86-48241	#	p 815	A86-48815	#	p 769
A86-47736	#	p 793	A86-48252	#	p 815	A86-48816	#	p 769
A86-47738	#	p 784	A86-48262	#	p 766	A86-48817	#	p 769
A86-47743	#	p 793	A86-48271	*	p 846	A86-48822	#	p 769
A86-47744	#	p 784	A86-48278	*	p 816	A86-48824	#	p 769
A86-47745	#	p 784	A86-48281	#	p 846	A86-48825	#	p 770
A86-47756	#	p 784	A86-48285	#	p 843	A86-48829	#	p 800
A86-47757	#	p 793	A86-48288	#	p 847	A86-48830	#	p 847
A86-47758	#	p 794	A86-48296	#	p 816	A86-48833	#	p 770
A86-47759	#	p 784	A86-48302	#	p 816	A86-48834	#	p 770
A86-47760	#	p 784	A86-48308	#	p 797	A86-48838	#	p 770
A86-47763	#	p 761	A86-48311	#	p 847	A86-48839	#	p 770
A86-47768	#	p 794	A86-48312	#	p 816	A86-48841	#	p 770
A86-47769	#	p 787	A86-48369	#	p 816	A86-48842	#	p 770
A86-47776	#	p 794	A86-48370	#	p 797	A86-48843	#	p 770
A86-47777	#	p 794	A86-48371	#	p 838	A86-48844	#	p 832
A86-47778	#	p 781	A86-48372	#	p 787	A86-48845	#	p 800
A86-47779	#	p 794	A86-48428	#	p 766	A86-48846	#	p 848
A86-47780	#	p 810	A86-48452	#	p 766	A86-48849	#	p 771
A86-47781	*	p 794	A86-48454	#	p 766	A86-48850	#	p 800
A86-47782	#	p 794	A86-48455	#	p 766	A86-48856	#	p 761
A86-47783	#	p 795	A86-48457	#	p 838	A86-48876	#	p 855
A86-47784	*	p 795	A86-48458	#	p 766	A86-48877	#	p 800
A86-47785	#	p 795	A86-48465	#	p 767	A86-48879	#	p 816
A86-47786	#	p 812	A86-48467	#	p 797	A86-48880	#	p 761
A86-47787	#	p 795	A86-48468	#	p 797	A86-48881	#	p 771
A86-47788	#	p 810	A86-48531	#	p 810	A86-48882	#	p 771
A86-47789	#	p 795	A86-48564	#	p 788	A86-48883	#	p 800
A86-47790	#	p 810	A86-48568	#	p 767	A86-48885	#	p 800
A86-47791	#	p 838	A86-48576	#	p 797	A86-48886	#	p 801
A86-47792	#	p 838	A86-48577	*	p 853	A86-48887	#	p 854
A86-47793	#	p 795	A86-48581	#	p 788	A86-48888	#	p 848
A86-47794	#	p 796	A86-48590	*	p 855	A86-48889	#	p 785
A86-47795	#	p 796	A86-48594	#	p 798	A86-48890	#	p 801
A86-47796	#	p 796	A86-48595	#	p 853	A86-48891	#	p 832
A86-47797	#	p 796	A86-48596	*	p 855	A86-48892	#	p 854
A86-47798	*	p 831	A86-48597	#	p 855	A86-48895	#	p 801
A86-47799	#	p 796	A86-48647	#	p 847	A86-48896	#	p 801
A86-47800	*	p 796	A86-48651	#	p 761	A86-48897	*	p 761
A86-47801	#	p 796	A86-48652	#	p 761	A86-48898	#	p 801
A86-47802	*	p 797	A86-48653	#	p 767	A86-48899	#	p 761
A86-47803	#	p 841	A86-48654	*	p 767	A86-49000	#	p 762
A86-47902	#	p 855	A86-48655	#	p 831	A86-49003	#	p 848
A86-47971	#	p 838	A86-48656	#	p 847	A86-49004	#	p 832
A86-48041	#	p 846	A86-48657	#	p 798	A86-49005	#	p 832
A86-48042	#	p 846	A86-48658	#	p 847	A86-49006	#	p 832
A86-48097	#	p 842	A86-48659	#	p 798	A86-49007	#	p 771
A86-48101	#	p 812	A86-48660	#	p 798	A86-49008	#	p 771
A86-48102	#	p 812	A86-48662	#	p 798			
A86-48103	#	p 812	A86-48663	#	p 798			
A86-48116	#	p 812						

ACCESSION

A86-49009	#	p 772	A86-49119	#	p 803	N86-31527	#	p 763
A86-49010	#	p 801	A86-49120	#	p 803	N86-31528	#	p 763
A86-49011	#	p 772	A86-49121	#	p 804	N86-31529	#	p 763
A86-49012	#	p 772	A86-49122	#	p 776	N86-31531	#	p 781
A86-49013	#	p 772	A86-49124	#	p 804	N86-31532	#	p 781
A86-49014	#	p 772	A86-49125	#	p 818	N86-31535	#	p 781
A86-49016	#	p 788	A86-49126	#	p 818	N86-31536	#	p 781
A86-49017	#	p 788	A86-49127	#	p 849	N86-31539	#	p 781
A86-49018	#	p 788	A86-49128	#	p 849	N86-31541	#	p 782
A86-49020	#	p 843	A86-49129	#	p 804	N86-31542	#	p 782
A86-49021	#	p 843	A86-49131	#	p 811	N86-31543	#	p 782
A86-49022	#	p 801	A86-49132	#	p 804	N86-31548	#	p 786
A86-49023	#	p 833	A86-49133	#	p 849	N86-31549	#	p 786
A86-49024	#	p 839	A86-49136	#	p 849	N86-31551	#	p 789
A86-49025	#	p 833	A86-49137	#	p 804	N86-31552	#	p 789
A86-49026	#	p 833	A86-49138	#	p 804	N86-31554	#	p 789
A86-49027	#	p 772	A86-49139	#	p 835	N86-31555	#	p 789
A86-49028	#	p 772	A86-49142	#	p 811	N86-31556	#	p 789
A86-49030	#	p 773	A86-49143	#	p 840	N86-31558	#	p 789
A86-49031	#	p 773	A86-49144	#	p 849	N86-31562	#	p 806
A86-49032	#	p 773	A86-49145	#	p 849	N86-31563	#	p 806
A86-49033	#	p 773	A86-49148	#	p 849	N86-31564	#	p 806
A86-49034	#	p 788	A86-49149	#	p 811	N86-31565	#	p 806
A86-49035	#	p 785	A86-49174	#	p 776	N86-31566	#	p 835
A86-49036	#	p 785	A86-49244	#	p 835	N86-31567	#	p 806
A86-49037	#	p 782	A86-49245	#	p 776	N86-31568	#	p 806
A86-49039	#	p 833	A86-49288	#	p 804	N86-31569	#	p 807
A86-49040	#	p 848	A86-49441	#	p 777	N86-31570	#	p 807
A86-49041	#	p 833	A86-49443	#	p 782	N86-31571	#	p 807
A86-49042	#	p 773	A86-49444	#	p 804	N86-31572	#	p 807
A86-49043	#	p 773	A86-49448	#	p 782	N86-31573	#	p 807
A86-49044	#	p 774	A86-49464	#	p 783	N86-31574	#	p 808
A86-49045	#	p 774	A86-49476	#	p 835	N86-31575	#	p 808
A86-49046	#	p 774	A86-49478	#	p 805	N86-31576	#	p 808
A86-49047	#	p 833	A86-49498	#	p 811	N86-31577	#	p 808
A86-49048	#	p 834	A86-49507	#	p 854	N86-31578	#	p 808
A86-49049	#	p 774	A86-49509	#	p 805	N86-31579	#	p 808
A86-49050	#	p 774	A86-49566	#	p 856	N86-31580	#	p 811
A86-49051	#	p 810	A86-49571	#	p 857	N86-31581	#	p 811
A86-49052	#	p 782	A86-49572	#	p 849	N86-31582	#	p 819
A86-49053	#	p 785	A86-49573	#	p 777	N86-31585	#	p 819
A86-49054	#	p 785	A86-49575	#	p 856	N86-31586	#	p 819
A86-49055	#	p 802	A86-49576	#	p 777	N86-31587	#	p 819
A86-49056	#	p 834	A86-49577	#	p 777	N86-31588	#	p 820
A86-49057	#	p 834	A86-49578	#	p 777	N86-31589	#	p 820
A86-49058	#	p 839	A86-49579	#	p 777	N86-31590	#	p 835
A86-49059	#	p 839	A86-49580	#	p 778	N86-31591	#	p 835
A86-49060	#	p 839	A86-49581	#	p 778	N86-31592	#	p 836
A86-49061	#	p 839	A86-49582	#	p 778	N86-31593	#	p 836
A86-49064	#	p 816	A86-49584	#	p 778	N86-31598	#	p 840
A86-49066	#	p 782	A86-49585	#	p 778	N86-31602	#	p 840
A86-49067	#	p 782	A86-49586	#	p 778	N86-31604	#	p 840
A86-49068	#	p 848	A86-49588	#	p 779	N86-31827	#	p 850
A86-49069	#	p 786	A86-49589	#	p 779	N86-31860	#	p 850
A86-49070	#	p 834	A86-49590	#	p 779	N86-31872	#	p 851
A86-49071	#	p 834	A86-49591	#	p 779	N86-31917	#	p 851
A86-49074	#	p 775	A86-49592	#	p 779	N86-32249	#	p 856
A86-49075	#	p 839	A86-49593	#	p 779	N86-32390	#	p 782
A86-49077	#	p 843	A86-49611	#	p 818	N86-32392	#	p 782
A86-49079	#	p 817	A86-49614	#	p 818	N86-32393	#	p 782
A86-49080	#	p 775	A86-49620	#	p 818	N86-32408	#	p 782
A86-49081	#	p 802	A86-49625	#	p 780	N86-32416	#	p 787
A86-49082	#	p 848	A86-49627	#	p 854	N86-32418	#	p 787
A86-49083	#	p 786	A86-49637	#	p 788	N86-32419	#	p 789
A86-49084	#	p 762	A86-49638	#	p 805	N86-32425	#	p 808
A86-49085	#	p 811	A86-49676	#	p 780	N86-32428	#	p 809
A86-49088	#	p 817	A86-49681	#	p 783	N86-32429	#	p 809
A86-49089	#	p 817	A86-49682	#	p 763	N86-32430	#	p 809
A86-49090	#	p 817	A86-49683	#	p 840	N86-32431	#	p 811
A86-49091	#	p 817	A86-49716	#	p 856	N86-32436	#	p 820
A86-49092	#	p 817	A86-49801	#	p 780	N86-32437	#	p 820
A86-49093	#	p 802	A86-49802	#	p 780	N86-32438	#	p 820
A86-49094	#	p 854	A86-49803	#	p 780	N86-32439	#	p 836
A86-49095	#	p 802	A86-49804	#	p 780	N86-32440	#	p 836
A86-49096	#	p 835	A86-49806	#	p 856	N86-32444	#	p 836
A86-49097	#	p 802	A86-49807	#	p 780	N86-32445	#	p 837
A86-49098	#	p 775	A86-49808	#	p 805	N86-32446	#	p 837
A86-49099	#	p 856	A86-49823	#	p 780	N86-32447	#	p 840
A86-49100	#	p 802	A86-49824	#	p 780	N86-32448	#	p 840
A86-49101	#	p 803	A86-49825	#	p 780	N86-32451	#	p 841
A86-49102	#	p 775	A86-49918	#	p 850	N86-32746	#	p 851
A86-49103	#	p 775	A86-49963	#	p 843	N86-32779	#	p 851
A86-49104	#	p 775	A86-49964	#	p 844	N86-32781	#	p 851
A86-49105	#	p 775	A86-50075	#	p 819	N86-32784	#	p 851
A86-49106	#	p 776	A86-50111	#	p 805	N86-32785	#	p 851
A86-49107	#	p 786	A86-50122	#	p 844	N86-33042	#	p 854
A86-49108	#	p 776	A86-50253	#	p 805	N86-33053	#	p 854
A86-49109	#	p 776	A86-50254	#	p 850	N86-33054	#	p 854
A86-49110	#	p 803	A86-50255	#	p 805	N86-33125	#	p 856
A86-49111	#	p 817	A86-50256	#	p 806	N86-33126	#	p 857
A86-49112	#	p 818	A86-50258	#	p 850			
A86-49113	#	p 818	A86-50259	#	p 786			
A86-49114	#	p 849	A86-50260	#	p 850			
A86-49115	#	p 803	A86-50269	#	p 781			
A86-49117	#	p 803	A86-50347	#	p 806			
A86-49118	#	p 803						

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